

Commonwealth of Pennsylvania
DEPARTMENT OF PUBLIC INSTRUCTION

COURSE OF STUDY IN SCIENCE
FOR GRADES SEVEN, EIGHT, AND NINE



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FOREWORD

THIS Course of Study in Science for grades seven, eight, and nine is intended for use in the Junior High School and also in grades seven and eight of the Elementary School, and the ninth grade of Four-year High Schools. It is a part of a suggestive twelve-year program of science prepared for the schools of the Commonwealth. The units have been so arranged that the course is adaptable for use in both 8-4 organizations and reorganized schools.

Science is becoming increasingly important in the school program. It is closely related to the everyday life of the individual. A knowledge of science is essential for an intelligent understanding of our environment and for appreciating the many phases of modern life. This course of study has been prepared to suggest types of exercises that give pupils experiences in dealing with natural phenomena.

In view of the fact that science is just now being introduced into the elementary school and into grades seven and eight of the junior high school, the procedures are given in more detail than might otherwise be necessary. In using the course, teachers are expected to make wide applications to local conditions. This may mean that certain phases of the course will be omitted and others will be changed materially so that they may be adapted to the school situation and life environment of the pupils.

The course was prepared by Arthur S. Clark, Supervisor of Science, Philadelphia Public Schools, under the general direction of Doctor E. E. Wildman, Director of Science, Philadelphia Public Schools. Materials in the course have been used experimentally in Philadelphia Public Schools. As adapted for state-wide use it is a part of a program of curriculum reorganization being developed under the direction of William H. Bristow, Chief, Education Bureau, Department of Public Instruction.

The procedure outlined in the course has been reviewed by a committee composed of J. S. Champion, Supervisor, Agricultural Education Division, Department of Public Instruction; Mrs. Edith D. Davison, Supervisor, Home Economics Education Division, Department of Public Instruction; Doctor George H. Ashley, State Geologist, Department of Internal Affairs; Doctor E. M. Gress, State Botanist, Department of Agriculture; R. L. Emerick, Department of Forests and Waters; S. S. Shearer, Director of Biological Science, State Teachers College, Shippensburg; and Miss Helen Purcell, Director of Elementary and Kindergarten Education, Department of Public Instruction. The preparation of the bulletin for publication is the work of Arthur S. Clark, Walter E. Hess, Supervisor, Secondary Education, and D. M. Cresswell, Department Editor.

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JAMES N. RULE

Superintendent of Public Instruction

CONTENTS

Introduction	5
Sequence of Units	7
Seventh Grade Course in Science	
UNIT I—Exploring Nature	9
UNIT II—The Earth's Crust	13
UNIT III—Fire— Friend and Foe	15
UNIT IV—How Heat Changes Substances	17
UNIT V—What the Sky Gives Us	19
UNIT VI—Magnetism and Electricity	22
UNIT VII—Making Use of Water	24
UNIT VIII—Flowers and Plants	27
Eighth Grade Course in Science	
UNIT I—Plant Products and Pennsylvania Forests	29
UNIT II—Sound	36
UNIT III—Modern Communication	38
UNIT IV—Modern Transportation	40
UNIT V—Things and How They are Moved	42
UNIT VI—Air and Weather	44
UNIT VII—Gardening	46
UNIT VIII—Plant Friends and Plant Enemies	48
Ninth Grade Course in Science	
UNIT I—Characteristics of Living Things	52
UNIT II—Common Elements and Compounds	61
UNIT III—Light	66
UNIT IV—Measurements and Calculations	69
UNIT V—Stars and the Solar System	71
UNIT VI—Making Use of Heat	74
UNIT VII—Relation of Plants and Animals to Man	77
UNIT VIII—Relation of Man to His Environment	82
APPENDIX A—Suggested Plan for General Science and Biology Class Room Laboratory ..	84
APPENDIX B—List of Supplies and Equipment	85
APPENDIX C—Visual-Sensory Aids in Junior High School Science	91
APPENDIX D—Bibliography	97



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COURSE IN SCIENCE—GRADES SEVEN, EIGHT, AND NINE

INTRODUCTION

I. GENERAL PROGRAM OF SCIENCE

School work to be real must be related to life. An individual's life is concerned largely in reacting to his social and physical environment, hence a knowledge of science is necessary for a proper understanding of modern life. It was with this thought in mind that the present course in science has been prepared. An attempt has been made to develop a progressive and unified course from the kindergarten to the end of the ninth year. The work presented in this publication covers grades seven, eight and nine.

Science in the Elementary School

(Grades 1-6)

Within its specific fields, a study of science in the kindergarten and first six grades should center around familiar facts and phenomena. With these as a background, it should seek to give the pupil the beginnings of scientific knowledge; to lay the foundations for future scientific growth; to develop the habit of seeking information at its source; to protect and expand the child's interest in nature; to point out the need for preservation and development of natural resources; to set up the beginnings of a sense of the importance of science in the life of the world; and to fill the pupil with a desire for the truth and show him the need for proof.

Science in the 7th, 8th, and 9th Grades

In the seventh, eighth, and ninth grades this background is progressively enlarged and definitized. The experiences of others as recorded in books receive additional emphasis. The scope of the scientific experiment is expanded both as to purpose and material. The pupil is thus equipped to pursue more serious scientific problems in the Senior High School with considerable ability for individual investigation.

It is not the purpose of elementary science to offer a course in systematic biology, chemistry, or physics, nor even to prepare the child for such courses. Elementary science should acquaint him with the things that surround him, and with their relationship and significance to his own experiences.

II. OBJECTIVES OF SCIENCE IN JUNIOR HIGH SCHOOL YEARS

A. Knowledge

Of man's increasing ability to control his whole environment.

Of the social problems that arise as a result of this increasing control.

B. Abilities, Habits and Skills

The ability to discriminate between truth and "half-truth."

The ability to find truth by direct observation of nature, including the results of simple experiments. This is training in scientific method.

The ability to devise simple experiments to aid in solving problems.

The habit of care in handling apparatus and materials.

The habit of a worthy use of leisure.

Skill in observation.

Skill in recording results.

Skill in drawing conclusions.

C. Attitudes

A keen interest in nature.

A spirit of inquiry.

Suspended judgment in the absence of facts.

Tolerance.

III. METHOD

A. Three Major Educational Aims Have Been Kept in Mind

1. Children must have objective experience. Every unit therefore contains problems requiring the pupil to have objective contacts. The work of each unit is constructed so as to revolve about these problems.

2. As a result of their science training pupils should learn to follow simple directions accurately. Science can be made to contribute this training more definitely than any other field.

3. Pupils should learn to report observations from objective experience with accuracy and without bias or prejudice. This skill should be the unique contribution of science in realizing the objectives of education.

B. Seasonal Arrangement of Topics

The topics for the Science Course in grades seven, eight, and nine have been arranged so that certain topics come at the time of the year when they can be most appropriately related to life experiences.

C. The Psychological Background

Every unit has been developed according to psychological procedure. Nature brings her lessons to us through concrete, objective contacts with our immediate environment. At once the mind is confronted with a difficulty, in the form of an intriguing question or *Problem*. The individual's reaction to this, even in the youngest child, is to be exploratory or probing. He makes use of all his sensory equipment in his effort to gather the necessary facts to solve his problem. Here we have the basis for an *Experiment*. If properly guided the experiment presents to the child the correct method of gathering facts to solve the problem.

Having gathered the necessary facts for solving the fundamental problem question, the next natural reaction is to associate this information with related facts. The information gained in the experiment is used as a basis for the associative processes. This forms the *Development* portion of the topic. For very young children of the kindergarten and primary school this may take the form of conversations, the relating of simple experiences, bringing interesting facts and materials from home, playing games, singing appropriate songs, using pictures, etc. In the upper grades and junior high school it may well take the form of research, involving textbooks and other sources of information.

Following this comes the *Summary* or "What have we learned?" part of a lesson or unit. This is for the purpose of fixing the facts, skills, and attitudes acquired by the pupil. The summary may be used as a means of self-testing on the part of the pupil.

Among very young children, the recognition of the objects or things talked about in the lesson should satisfy this requirement. In the upper grades and in the junior high school other types of testing will be used. The summary proper should consist of a simple outline built by the class and teacher together. The teaching program suggested in this course includes four essentials;—first, the Problem; second, an Experiment (objective exploration); third, Development (association); fourth, Summary (self-testing and recapitulation).

D. Types of Experiments; and How to Direct Experiments

1. Teacher Experiment. In this type the teacher performs the experiment, but pupils individually must make their own observations.
2. Class Experiment. In this type a committee selected from the class sets up the apparatus, and, where necessary, reports on the progress of the experiment to the class.
3. Group Experiment. In this type pupils at each table or on each desk row perform the experiment or designated portions of it.
4. Unless the experiment is clearly marked as teacher, class, or group experiment it is to be performed by individual pupils, usually with 2 pupils working together.
5. Suggested procedure for directing an experiment. Teachers vary in the ways in which they handle experiments. It is essential that all pupils understand the statement of the problem experiment before the work is begun, comprehend the directions if a group or class experiment is to be performed and know what apparatus is required.
 - a. If work sheets are available the class should read silently the directions. The teacher may then answer necessary questions about the directions, calling particular attention to any parts that require special explanation or emphasis.
 - b. After the experiment has been performed, it is important to see that each observation is recorded in the pupil's notebook. That is, the experiment is to be written up step by step as the directions proceed.
 - c. After the experiment has been performed, conclusions should be noted. Emphasis should be laid on the fact that the information for answering the problem is to be obtained from the observations of the experiment.

E. The Work Sheet and the Notebook

Work sheets promote efficiency and are time-saving. They should be distributed at the beginning of the class period and collected at the end of the lesson. These sheets do not become the property of the pupils, hence only sufficient copies need be supplied for each class room.

Work sheets may be printed or mimeographed.

The notebook response upon the part of each pupil is valuable and necessary. In this course it is suggested that the following should appear as the minimum record for each experiment:

1. Statement of the "problems."
2. The "observations" in sentence form, or in tabular form where indicated.
3. The answer to "conclusion" questions or instructions in sentence form.

F. Development

Substitutions may be made for questions suggested or additional ones may be used. The Development may be curtailed or omitted for slow groups. It is designed to stimulate research work on the part of the pupil. It should present a challenge to the more brilliant pupils. The Development may be used weekly or immediately following the experiment. It should not, however, be assigned before the experiments pertaining to it have been performed. The preparation of the Development may be a home assignment. For this reason care and foresight must be exercised in selecting it. Formulate only questions to which answers can be secured from sources reasonably accessible to the pupil.

G. The Summary

The Summary should follow the study of each unit or part of a unit. The summaries suggested in the body of the course are offered as examples of what might be done. They are the summaries for the maximum of each topic. Summaries should be developed by teacher and class together. They must be brief and adapted to suit the assignment given to the class.

Opportunities for self-testing are suggested under each summary. They must be changed and adjusted to suit the assignment given to the class. It will be noted that certain words in the self-testing exercises are in italics. These may be taken as accepted completions of the statements, hence they may serve as a key when the sentences are presented to the pupils in the completion form.

H. Report and Films

These are to be used optionally in the fields of scientific biography, school journey, and original problems. Suggestions for suitable reports and films are made in connection with many of the topics, particularly in the ninth year outline.

I. Time Allotment

The course has been developed for the seventh, eighth and ninth grades in both reorganized schools and in schools having the eight-year elementary and four-year high school organization.

As outlined, the following minimum time allotment is suggested for three grades as follows:

Grade 7	120 minutes weekly
Grade 8	180 minutes weekly
Grade 9	240 minutes weekly

Where science is not offered in grades seven and eight the time allotment for grade nine will need to be increased to not less than 300 minutes weekly. In schools offering science only in grades eight and nine or in grade nine a selection of desirable units must be made. The course has been so arranged that it will be possible to combine certain of the units in such a way as to give a complete and integrated course.

SEQUENCE OF UNITS

This outline is arranged for schools beginning the course in the Fall term of each year. If any other plan is used the units selected should always be arranged on a seasonal sequence basis.

GRADE 7

<i>First Semester</i>		<i>Second Semester</i>	
Unit I*	Exploring Nature	Unit V	What the Sky Gives Us
Unit II	The Earth's Crust	Unit VI	Magnetism and Electricity
Unit III	Fire—Friend and Foe	Unit VII	Making Use of Water
Unit IV	How Heat Changes Substances	Unit VIII	Flowers and Plants

GRADE 8

<i>First Semester</i>		<i>Second Semester</i>	
Unit I	Plant Products and Pennsylvania Forests	Unit V	Things and How They are Moved
Unit II	Sounds	Unit VI	Air and Weather
Unit III	Modern Communication	Unit VII	Gardening
Unit IV	Modern Transportation	Unit VIII	Plant Friends and Plant Enemies

GRADE 9

<i>First Semester</i>		<i>Second Semester</i>	
Unit I	Characteristics of Living Things	Unit V	Stars and the Solar System
Unit II	Common Elements and Compounds	Unit VI	Making Use of Heat
Unit III	Light	Unit VII	Relation of Plants and Animals to Man
Unit IV	Measurements	Unit VIII	Man and His Environment

Where no program of science has been offered for Grades seven and eight, the following selection of units is suggested for the ninth year course:

- UNIT I —Characteristics of Living Things (Unit I, Grade 9)
- UNIT II —Fire and Heat (Selections from Units III and IV, Grade 7; and Unit VI, Grade 9)
- UNIT III —Measurements (Unit IV, Grade 9)
- UNIT IV —Common Elements of Compounds (Unit II, Grade 9)
- UNIT V —Sky and Stars (Selections from Unit V, Grade 7; and Unit V, Grade 9)
- UNIT VI —Electricity and Power (Selections from Unit VI, Grade 7; and Units III and IV, Grade 8)
- UNIT VII —Things and How They Are Moved (Unit V, Grade 8)
- UNIT VIII—Plants and Plant Products (Selections from Unit I, Grade 8; and Unit VII, Grade 9)

INTRODUCTORY LESSON—HOW DOES A SCIENTIST WORK?

This is the first lesson for seventh year classes starting in September or in February.

METHOD

The emphasis of the Introductory Lesson is to be placed on *what constitutes the parts of an experiment*. The teacher can do this best by raising a simple problem and solving it experimentally before the pupils. Suggested problems: “What happens when salt is put into water?” (Use tumbler of water and a little salt.) “Will a steel pen float on water?” (Use tumbler of water and a steel pen.) “Is a 2c stamp wider or longer than a 1c stamp?” (Use 1c postage stamp, 2c postage stamp, and rule.) “Which side of a square is longest?” (Draw a square on the blackboard and use a rule.)

* Note the Introductory Lesson below.

Emphasize to the pupils that *they* are going to answer the Problem questions with the help of actual materials (Apparatus) with which the teacher proposes to do definite things, and that they must follow directions in order to find out what will happen (Observation). The teacher may thus develop the idea of an experiment and of experimentation, writing on the board the headings: Problem (stating it as a question); Apparatus; Directions and Observations and Conclusions, as the lesson proceeds.

Have the pupils suggest the facts which may form the Conclusion. Stress the fact that scientists obtain their conclusions strictly from the results of experiment. They must always be able to prove their conclusions. Concerning the particular experiment of the lesson, drill on these questions: "What is the answer to our problem?" "How do you know?" Require definiteness. Do not accept: "It is proved by the experiment."

Make your blackboard outline of this initial lesson a model form for pupils to follow in recording all future experiments, keeping an accurate, neat, and correctly arranged notebook.

This lesson may be concluded by relating a few incidents about great scientists who have discovered truths of enormous value and usefulness to mankind through the proper knowledge of experimenting. Suggestions:

1. Benjamin Franklin's experiment with the kite.
2. Michael Faraday's discovery of the production of an electric current.
3. What Thomas Edison did for us through discoveries of Franklin and Faraday.
4. Louis Pasteur and "pasteurized" milk.
5. The discovery of the cause and control of yellow fever.

SEVENTH GRADE COURSE IN SCIENCE

UNIT I
EXPLORING NATURE

GENERAL OBJECTIVE

Getting Acquainted With Living Things

This is the first introduction to experimental observation of living forms. Emphasis is placed on the provision for seasonal adaptations.

SPECIFIC OBJECTIVES	PROBLEMS FOR EXPERIMENT	DESIRABLE OUTCOMES
Living Forms Provide for the Future		
Insects	1. How can we recognize an insect?	1. Appreciation of the fact that insects present a serious problem to mankind. 2. Knowledge that insects are the only creatures having 6 legs.
Flowers	2. What are the parts of a flower? 3. How can I learn some common wild flowers?	3. Appreciation of the fact that plants make provision for the future through development of seeds, providing means for their dispersal, and, when necessary, the storing of food through the work of leaves, roots and stems.
Ripening Fruits	4. Why do fruits change odor, color, and taste when they ripen?	
Leaves, Buds, Stems and Seeds	5. How do plants survive from year to year? 6. When do tree leaves work most actively?	

EXPERIMENT 1

A. Problem

How can we recognize an insect?

B. Experiment

1. Apparatus

House fly; mosquito; butterfly; ant; bee (or any other 5 insects which can be found easily).

2. Directions and Observations

- a. Observe the insects.* Count the number of wings and the number of legs on each. It is not necessary to handle the insects.

Record your observations as follows:

Name of insect	Number of wings	Number of legs

3. Conclusions

What characteristic is common to all insects which makes it possible for us to recognize them?

C. Development

Insects are more numerous than all the other kinds of animals taken together. (1) Why is this so serious a problem for mankind? (2) Why is the house fly, the mosquito, the clothes moth, or the Japanese beetle, a harmful insect? (3) What are the 4 life stages through which insects commonly pass? (4) What are the characteristics of each stage? (5) Are moths and butterflies harmful in all their life stages? Why? (6) How would you distinguish moths from butterflies?

EXPERIMENT 2

A. Problem

What are the parts of a flower?

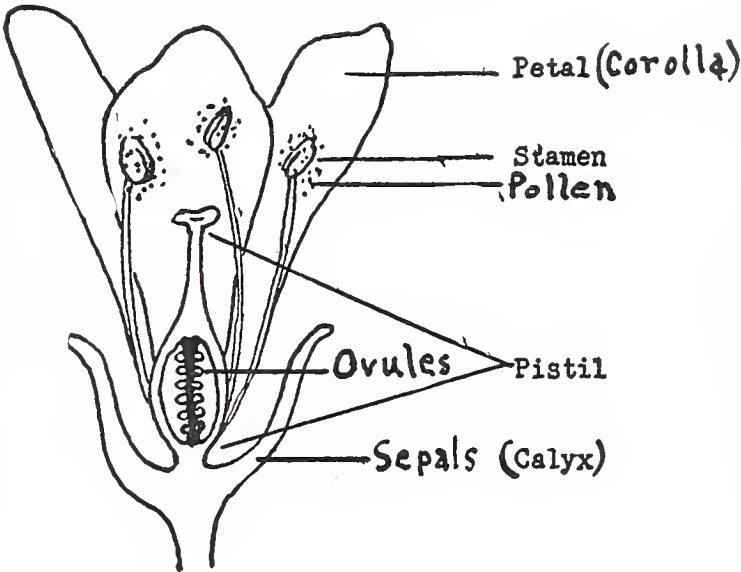


Figure 1

B. Experiment

1. Apparatus

Large blossom; needle.

2. Directions and Observations

Study the labelled drawing until you are familiar with the names and general location of the different parts.

- a. Looking down into the flower, identify as many of the parts as you can. Then

* See page 8 relative to instructions for recording observations.

carefully pull off 2 or 3 petals and look at the side view of the flower. By using the needle try to expose the swollen base of the pistil which contains the ovules.

b. Brush the ends of the stamens with the needle to see if you can find any pollen grains. Note their size.

c. Record your observations.*

3. Conclusions

To answer the problem question, copy the labelled drawing.

C. Development

(1) For what purpose does a plant produce flowers? (2) In order for seeds to form, where must the pollen journey and what must it then do? (3) How do insects help? (4) Do all flowers need insects to aid them? (5) What methods do these flowers use? (6) Examine as many kinds of flowers as possible to see how their parts differ in color, shape, number, and arrangement. Of what importance are these characteristics in plant classification?

C. Development

(1) What is a single flower? (2) What is a composite flower? (3) What are disk and ray flowers? Give illustrations. (4) What is a complete flower? Give illustrations.

EXPERIMENT 4

A. Problem

Why do fruits change odor, color, and taste when they ripen?

B. Experiment

1. Apparatus

Ripe tomato; apple; sharp knife.

2. Directions and Observations

a. Examine the tomato and apple with regard to the following qualities: attractiveness of coloring; whether the odor of each is appetizing or disagreeable; whether the taste is pleasant or unpleasant. Determine the taste from small pieces which have been passed around. This change in color, odor, and taste is called "ripening."

Place the tomato and apple on the table. With the sharp knife make a cross-section of each fruit. Note the seed chambers and how the seeds are arranged. (In the apple you will notice that the seeds are enclosed in chambers, the walls of which are very tough and hornlike.)

b. Make a diagram sketch of each cross-section. Label the following parts: tough outer skin; soft, pulpy wall; seed chambers; seeds. In the apple, label also the tough shell forming the seed chambers.

c. Examine the tomato seed. Note the jelly-like substance surrounding each seed. Try to pick up some of the seeds between the fingers. This jelly is attractive to animals.

d. State how apples attract animals.

3. Conclusions

Fruits like the tomato and apple require the help of animals to liberate their seeds. What advantage is it for fruits to change their odor, color, and taste when they ripen their seeds? What use does the plant make of its fruit?

C. Development

(1) What organ of the flower becomes the fruit? (2) Some fruits have soft, edible walls and pulp. Give examples. The present day cultivated apple and tomato are very different from their original "wild" ancestors. (3) Do you know any other fruits which man has been able to improve for his own use? (4) Name 3 fruits that ripen in the spring. (5) Name 3 that ripen in the summer. (6) Name some fruits used by man for purposes other than food.

EXPERIMENT 5

A. Problem

How do plants survive from year to year?

B. Experiment

1. Apparatus

In September use the following: Small tree branch bearing leaves; pod from a catalpa tree, or milkweed pod; burdock bur, beggar tick, or tick trefoil; turnip, beet, or carrot;

EXPERIMENT 3

A. Problem

How can I learn some common wild flowers?

B. Experiment

1. Apparatus

In September use the following:
Colored pictures or living plants of clover, goldenrod, sunflower, wild aster, wild carrot, thistle.

In June use the following:
Colored pictures or living plants of violet, dandelion, tulip or narcissus (select one), buttercup, wild mustard, daisy.

2. Directions and Observations.

Your teacher will show the class the pictures or the actual plants. Observe them carefully until you can answer the following questions about each: (1) What is the color of the flower? (2) About how large is the flower? (3) By what arrangement are the flowers placed on the stem? (4) How large are the leaves? (5) Are the leaves pointed or blunt, smooth-edge or uneven? (6) About how tall was the plant on which the flower grew?

a. Record your observations as follows:

Name of wild flowers	Color of the flower	Shape of the leaves	Height of the plant

b. If you can find any of these wild flowers put a V before its name in the chart. You may also add another column headed "Where They Grow" and state for each "shady place," "sunny field or lot," "by the roadside," etc.

3. Conclusions

What factors must you consider to help you recall the common wild flowers?

* See page 8 relative to instructions for recording observations.

stalk of celery; section of head of cabbage; portion of cauliflower.

In June use the following:

Small tree branch bearing leaves; maple keys or heads of dandelion seeds; burdock bur saved from the September collection; turnip, beet, or carrot; stalk of celery; section of a head of cabbage; portion of cauliflower.

2. Directions and Observations.

- Examine the tree branch to learn what is attached to it just above the point where the leaf grows.
- Carefully pull off a few of the leaf-stalks to see whether these knobs will remain on the branch after the leaves have fallen. These little knobs are buds. Inside of them are the leaves for next spring.
- Examine seeds which have appendages attached to them. Notice how the seeds are arranged.
- Lay two or three seeds with their appendages intact on the palm of your hand. Blow them up into the air. Notice how they behave and whether they land close to you or at some distance.
- Examine the burdock seed, looking carefully at the hooklike parts. Place the seed on your coat sleeve. Note whether it is easy to shake off.
The turnip, celery, cabbage, and cauliflower are examples of plants which must prepare to live over the winter by storing food in some part of their bodies.
- Examine each of these vegetables to find out whether the food storehouse is in the root, leaves, stem or flower.

3. Conclusions

In telling how some plants survive from year to year explain (a) how trees prepare to replace the fallen leaves; (b) how plants like the catalpa and burdock help their seeds to scatter over the soil; (c) how plants like the turnip, celery, cabbage, and cauliflower prepare for winter.

C. Development

- What are the 4 methods which different plants use to distribute their seeds? (2) Why is it best for the parent plant to have its seeds scattered? (3) What are the 4 methods used by plants for storing food? (4) What is meant by the terms annuals and biennials? Give examples. (5) Which type would have to provide a storage place for food?

EXPERIMENT 6

A. Problem

When do tree leaves work most actively?

B. Experiment

1. Apparatus

Foot rule; twigs about 12 inches long of 2 or 3 common trees.

2. Directions and Observations

- Measure from the growing end of the branch back to the first ring around the twig, which marks the present season's growth.
- Measure back to the second ring, which marks last year's entire growth, and compare with the amount of growth made so far in the present season. This will show you when most growth is accomplished.

Without leaves a plant could not make the food necessary for growth.

- Count the number of leaves produced this season. Compare with the number produced last season. (How can you count last season's leaves?)
- Make studies of several kinds of trees to see whether all have grown this year with equal rapidity. (It is not necessary to break branches to determine this.)

In finding the length of this season's growth use a foot rule or your measured span (the distance from the tip of the second finger to the tip of the thumb when the hand is out-stretched) as the measuring unit.

If the name of any tree is not known, a leaf from that tree or a drawing of it should be brought to school in order that it may be identified in a tree book.

- Record your observations as follows:

Names of trees	Length of twig growth this year	Length of twig growth last year	Number of leaves on new growth	Number of leaves on last year's growth

3. Conclusions

When do the leaves work most rapidly. Do all kinds of trees grow with equal rapidity? Does there seem to be any relation between the rapidity of seasonal growth and the number of leaves?

C. Development

- Of what use are leaves to trees? (2) How early in the summer is the season's growth completed? (3) Why is it that tree leaves begin to fall in the autumn? (4) Why are the sap tubes sealed at the scar? (5) What sort of trees in our latitude retain their leaves all year round? (6) Do tropical trees lose their leaves as our trees do? Why? (7) How can you tell when the leaves are ready to fall? (8) What causes many tree leaves to change color just before they fall from the tree?

SUMMARY

Insects are so numerous and multiply so rapidly that it is difficult to control the harmful ones.

Life Stages of an Insect

Hatching or *egg* stage
Feeding or *larva* stage
Resting or *pupa* stage
Egg laying or *adult* stage.
All insects have *six* legs.

Some Harmful Insects

Name of insect	Harmful stage	Harmfulness
housefly	adult	spreads disease
mosquito	adult	spreads malaria in temperate zones and yellow fever in tropics
clothes moth	larva	destroys woolen goods
Japanese beetle	larva and adult	eats plant roots eats plant leaves, flowers fruits

The flower is the place where the plant forms *seeds*.

The pollen is carried from the *stamen* to the *pistil*, where it must unite with the *ovules* or no seeds can form.

Flowers with bright-colored petals and nectar make use of *insects* to transfer the pollen. Flowers without bright colors or nectar (corn, forest trees, grasses) have their pollen carried by the *wind*.

Most of the fall flowers are *composite* flowers. Most of the spring flowers are *single* flowers.

Composite flowers are made up of disk and ray flowers. The disk flowers are florets consisting of *stamens* and *pistils*. These are surrounded by a collection of ray flowers, composed of *petals*.

Single flowers have *stems* of their own, even if arranged in *groups* on one stalk.

Most *single* flowers are complete, having their own *stamens*, *pistils*, *petals*, and *sepals*.

Note: In many cultivated flowers sepals, stamens, or pistils have been changed to petals. Tulips, peonies, and roses are illustrations.

Ripening of fruit is an effort of a plant to scatter its *seeds* by the aid of *animals* which *eat* the fleshy parts, permitting the seeds to *escape*.

Man uses many of the *fleshy* fruits for his own food. He has developed these fruits to improve the *taste*, *form*, and other qualities which nature originally gave them.

How Plants Survive from One Year to the Next

Trees. Trees provide *buds* on their branches which contain *leaves* for the coming year. Leaves change *color* and drop when their work for the year is complete.

Seeds and Seed Scattering. Seeds are scattered in order that they may have a chance to reach good *soil* and escape their *enemies*. Seeds may be scattered by *wind*, by *force* developed by the plant itself, by *animals*, by *man* for his own use.

Annuals and Biennials. Plants which produce seeds the second year store food in *roots*, *stems*, *leaves*, or *flowers*. They are called *biennials*. Plants which produce seeds and die within one season are called *annuals*.

Practically the entire season's growth is made during the *first* weeks of the summer season.

Leaves give off to the air excess *water* absorbed by the roots, and make *food* for the growing plant. In autumn, when the air cools, the absorption of *water* stops and also the making of *food*. Hence the leaves become unnecessary and gradually *dry* up and *fall* off.

In our latitude *evergreens* like the pines, firs, and hemlocks retain their *leaves* throughout the winter.

NOTES ON METHOD

Experiment 2

1. Any single type flower will serve.
2. Discourage the indiscriminate picking of wild flowers by pupils. Nature's living forms are most beautiful when left in the setting which she has wisely selected for them. One flower per pupil is quite sufficient for study purpose.
3. Distinguish clearly between a flower and a plant. Children rarely do this.

UNIT II

THE EARTH'S CRUST

GENERAL OBJECTIVES

A. How Man Uses the Earth's Crust

The objectives are:

1. To appreciate that there are differences in the structure and appearance of rocks which define their usefulness.
2. To know that rocks are used for purposes of building construction and ornamentation, as a source of valuable minerals and metals, as the source of jewels.

B. The Formation of Soil

The objective is:

To show the relation of soil to rock.

SPECIFIC OBJECTIVES	PROBLEMS FOR EXPERIMENT	DESIRABLE OUTCOMES
Rocks and Their Uses		
Kinds of Rocks	1. How does nature make the rocks? (Teacher experiment) 1a. Are all rocks alike?	Knowledge: 1. That rocks differ in structure and composition.
	2. How does man use rocks?	2. Of the use of rocks in the community.
Cement and Plaster	3. How does man make rocks? (group experiment)	
Smelting	4. How does man get metals from rocks?	3. That rocks contain valuable minerals which scientists have shown how to obtain.
Soil		
Erosion	5. Of what is the soil made? 6. How does nature make soil? (class experiment)	4. That soil is rock particles finely ground by erosive agencies.
Soil Holds Water	6a. How do soil particles hold water? (class experiment)	5. That soil is used as a water reservoir.

NOTES ON EXPERIMENTS

Experiment 1 should consist of an examination of quartz, granite, limestone, sandstone, marble and soil and these demonstrations: what happens when a glass tubing is left in the flame for sometime; how shaking soil and water together in a glass jar causes particles to form in layers when allowed to settle. **Experiment 1-a** implies the examination of various types of rocks with a view to the qualities they possess such as hard or soft, does it soak in water, is it affected by acid? **Experiment 2** should consist in identifying rocks used for different purposes in various buildings of the neighborhood. **Experiment 3** should consist of making small amounts of plaster of Paris and concrete. **Experiment 4** may well be performed by heating a pinch of oxide of mercury to observe the separation of the metal. **Experiment 5** should consist of an examination of gravel, sand, clay and leaf mould with reference to color, materials composing it, and coarseness of particles. **Experiment 6** may consist of passing carbon dioxide through lime water and observing the result as demonstrating the chemical method of producing soil; and of shaking limestone chips in a can of water to demonstrate the mechanical method of producing soil. **Experiment 6-a** may consist of weighing pebbles before and after wetting them to show how much water clings to their surfaces.

DEVELOPMENT

Experiments 1 and 1-a: (1) Rocks form what part of the earth's crust? (2) Do rocks ever change? What are some

proofs of this? (3) What type of rock is formed by the action of volcanoes? (4) Can you name a region where this is taking place today? (5) What are fossils? (6) What do they show? (7) How could they have been formed in rock which is today many feet below the earth's surface?

Experiment 2: (1) Why is granite chosen instead of the other types of rock for paving stones? (2) Which stone is used most for monuments? Why? (3) What may be one cause of the lettering on very old monuments becoming blurred and unreadable? (4) Select five buildings in your neighborhood which have in them any of the five rocks you have studied. (5) Tell which are used for construction purposes and which are used for ornamentation.

Experiment 3: (1) To what use is concrete put in outdoor construction? (2) What advantage has concrete over brick and natural stone in building construction? (3) What is reinforced concrete? (4) For what is it used? (5) From what materials is Portland cement made? Bricks, terra cotta, chinaware, and glass are also artificially made rock. (6) Find out from what materials each is made. (7) What makes bricks turn red when they are baked? (8) What do we mean when we say cement or plaster "sets"?

Experiment 4: (1) What name is given to minerals from which metals are extracted? (2) What is meant by "smelting"? (3) What is a blast furnace? (4) For what is it used? (5) What is "pig iron"? (6) Why are gold and silver called "precious stones"? (7) For what purpose are they generally used? (8) How would you recog-

nize a ruby, an emerald, a sapphire, a topaz, an amethyst, a diamond? (9) Would this method be a reliable one to use in purchasing any of these stones? Why?

Experiment 5: (1) Does nature ever make rocks from soil? (Refer to Experiment 1 before explaining.) Air found between the particles of soil is called soil air. (2) Will gravel, clay, or sand contain most soil air? Why? (3) What is meant by organic soil? (4) What is meant by inorganic soil? (5) Which types of soil studied in this lesson are inorganic? (6) Which organic? (7) In which of these types of soil will plants grow best? Why? (8) Which of these types is called humus?

Experiments 6 and 6-a: (1) What does the word erosion mean? Soil is made by erosion. (2) List four ways other than the ones illustrated in the experiment by which rocks may be eroded. (3) What would the presence of rounded pebbles tell you about the past history of a region? (4) Under what circumstances will water erode soil? (5) What does sedimentation mean when applied to soil formation? (6) Under what circumstances will water build up soil deposits?

SUMMARY

Rocks are the *solid* part of the hard crust of the earth.

The Types of Rocks

Igneous or *fire* made rocks, such as *quartz* and *granite*.

Stratified, or rocks laid down in *layers* under *water*, such as *limestone*.

Metamorphic, or *reheated* rock, such as *marble*.

Rocks which are *hard*, unaffected by *acids*, and which will not absorb *water* are best for building.

Rocks of agreeable *color* and soft enough to be readily *cut* or *polished* are generally used for ornamentation.

Concrete is a mixture of *cement*, *sand*, and *pebbles* which slowly hardens in the presence of water. Reinforced concrete is concrete having supports of *iron* run through it when it is being moulded.

Concrete is used for making *roads* and *pavements* and as a foundation support for *buildings*.

Plaster of Paris is a soft, *quick* hardening artificial stone. It is used for surfacing *walls* and for making small statues and ornaments.

Bricks, terra cotta, and chinaware are made of *clay* baked very hot.

Glass is made of *sand* mixed with other materials heated very hot until they melt together.

Mineral *ores* are rocks containing metals combined with other substances. Metals are usually freed from the *ore* by *heating*.

Soil is ground up *rock* material which is sometimes mixed with *plant* and *animal* remains.

The coarsest soil is *gravel*; finer soil is *sand*; very finely powdered soil is *clay*; plant and animal remains mixed with *clay* is called *humus*.

Soil is made by the erosion of *rock*. Erosion means *wearing* away.

Some Ways by Which Erosion Takes Place

Action of *wind*; mechanical action of *water*; chemical action of *water*; scraping action of *glaciers*; water *freezing* in crevices of rock; action of plant roots in rock *crevices*.

UNIT III

FIRE—FRIEND AND FOE

GENERAL OBJECTIVES

A. The Relation of Air to Burning

The objective is to show that the burning process is controlled by increasing or decreasing the air supply.

B. Oxidation and Carbon Dioxide

The objectives are

1. To show that oxidation may occur with or without burning.
2. To realize that carbon dioxide, a gas easily prepared, is one of the best fire extinguishers.
3. To investigate certain practical applications of the oxidation process.

SPECIFIC OBJECTIVES	PROBLEMS FOR EXPERIMENT	DESIRABLE OUTCOMES
Air is Related to Burning Controlling Fire	1. Why does stepping on a lighted match put it out? (class experiment) 1a. What is a flame?	Knowledge: 1. An air supply is necessary for burning while exclusion of air extinguishes a fire. 2. The flame is a sign of burning.
Oxygen, the Fire Gas	2. What proportion of the air supports burning? (class experiment)	3. Oxygen is the air gas which supports burning.
Some Effects of Oxidation Oxidation Without Fire	3. Can a substance combine with oxygen without producing a flame? (class experiment) 3a. Why does paint harden? (class experiment)	4. Oxidation occurs without fire as in rusting and paint hardening.
Carbon Dioxide—the Fire Extinguisher	4. What makes the bubbles in soda water? (group experiment) 5. How does a scientist detect carbon dioxide? 6. How can we make a fire extinguisher? (teacher experiment)	5. Carbon dioxide is the ideal fire extinguisher. 6. Carbon dioxide can be prepared easily in practical fire extinguishers. 7. Of the construction and operation of a common fire extinguisher.

NOTES ON EXPERIMENTS

Experiment 1 may be performed by observing how a lighted candle is extinguished when placed in a covered jar. **Experiment 1-a** demonstrates the three parts of a flame by thrusting a match stick at the base, near the wick and at the tip of a candle flame as illustrated in figure 2. **Experiment 2** should show how water rises in a wide-mouth bottle when the inverted bottle is placed over a candle and the oxygen is allowed to burn out as illustrated in figure 3. **Experiment 3** may be performed by placing iron filings in a test tube with a little water,

inverting it and showing how the iron has oxydized as illustrated in figure 4. **Experiment 4** may be performed by placing baking soda in a bottle partly filled with water, adding lemon juice and corking quickly. **Experiment 5** should show how carbon dioxide may be detected by limewater as illustrated in figure 5. **Experiment 6** should follow the ordinary instructions given in the general science text.

DEVELOPMENTS

Experiments 1 and 1-a: (1) What is the best way to make a fire burn? (2) How do we check our furnace

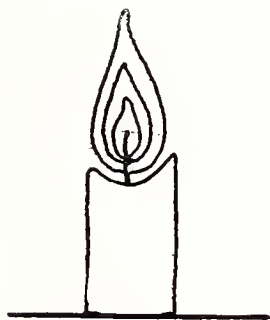


Figure 2

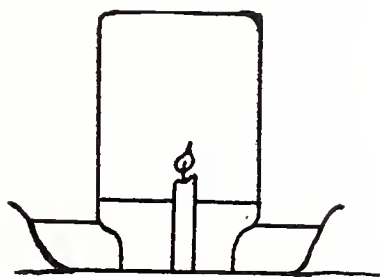


Figure 3

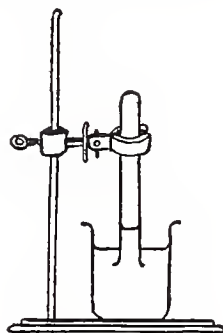


Figure 4

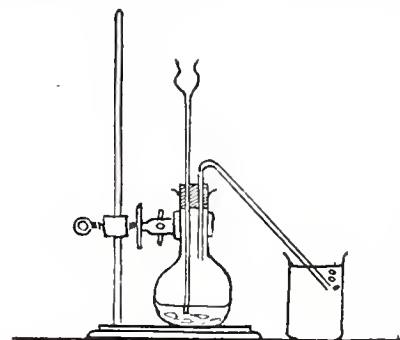


Figure 5

fires? (3) Make a drawing of the way in which air goes through a furnace fire. (4) How do we cause a smouldering fire to burn? (5) A rug or carpet thrown over a small fire extinguishes it. Why? (6) Why will closing steel shutters on warehouses help put out a fire? (7) What was Argand's invention? (8) What is burning? Only inflammable materials can burn. (9) Make a list of five inflammable materials. (10) Why is it that glass, asbestos, and air do not burn? (11) What name is applied to materials of this class? (12) What is kindling temperature? (13) How is the Bunsen type flame produced? (14) What is its advantage over the ordinary flame? (15) Name at least two places in the home where the Bunsen type is employed. (16) How would you know when the air supply was correctly regulated in your gas range burners? (17) How high should the gas range flame be with relation to the cooking vessel to give the greatest amount of heat?

Experiment 2: (1) What is the name of the gas in the air which supports burning? (2) What are the names of other important gases in the air? (3) What is the proportional composition of the air in your school room? (4) Why is Joseph Priestley's name thought of in connection with this subject? (5) Burning is one form of oxidation. (6) What does oxidation mean?

Experiment 3: Oxidation may occur rapidly or slowly. (1) Is combustion slow or rapid oxidation? (2) Can you account for a possible fire in a hay-stored barn? (3) What happens to iron when exposed to the air? (4) What type of oxidation does this illustrate? (5) How does rust affect bridges and other steel structures? (6) How can the disintegration of iron structures be prevented? (7) Report any examples of slow oxidation that you can observe. (8) What substance is used to polish stoves? Why? (9) What is galvanized iron? (10) What is the reason for galvanizing iron? (11) What color is zinc rust? Look at an old washboard. (12) What substances are used to make paint? (13) Why is the oil added? (14) Why is turpentine sometimes added? (15) How is paint made? (16) Why do painters' clothes take fire so easily? (17) What can happen if oil-soaked woolen or cotton rags are left about the house in out-of-the-way places? (18) What is spontaneous combustion? (19) What precaution should be taken with oily rags if we desire to keep them? (20) What is decay?

Experiment 4: (1) When baking soda is mixed with tomato juice a foaming takes place. Why? (2) How did soda water get its name? (3) What causes the action of a Sedlitz Powder? (4) What is the action of sour milk and baking soda in cake-making? (5) What makes the holes in cheese? (6) How do soda mints act in the stomach? (7) What happens when water is put into baking powder? Why?

Experiment 5: (1) Why is it necessary to ventilate a room? (2) Is a gas heater a good means of warming a bedroom? Why? (3) What gas comes from marble chips when hydrochloric acid is poured on them? (4) How does nature remove the carbon dioxide in winter? (5) If you had a bottle of carbon dioxide and a bottle of oxygen, both unlabelled, how could you tell which each was?

Experiment 6: (1) Have pupils visit the fire house and examine method used on chemical fire engines. (2) Examine portable extinguisher in school.

SUMMARY

To make things burn *air* is needed. We can make a fire burn by fanning *air* to it. A smouldering fire can be made to burn by giving it a *supply* of *air*.

To put out a fire we must exclude *air*. We check a furnace fire by *closing* the *air* openings to and from the fire. A rug thrown over a small fire will extinguish it because it *excludes* the *air* supply to the fire.

A flame indicates that *burning* is taking place. *Burning* is the uniting of an *inflammable* substance with *oxygen* of the *air*. The gas of the candle burns only where it is in contact with the *air*. The temperature at which a gas begins to burn is called its "*kindling* temperature." A flame is a *gas* in the process of *burning*.

Pure air contains *oxygen* which supports burning. This gas makes up 1/5 of the volume of the air. In burning this gas *combines* with other substances. Joseph Priestley discovered *oxygen* August 1, 1774.

The combining of a substance with *oxygen* is called oxidation. Combustion is the combining of a substance with *oxygen* at such a rapid rate as to produce *heat* and *light*. Rust is the slow combination of iron with *oxygen*. Steel and iron structures have to be protected from *oxygen* in the air by a coating of paint.

Paint is a mixture of *linseed* oil and a pigment, such as white lead. Oil in paint *hardens*, it does not dry.

Oily rags take fire because of *oxidation* which produces *heat*. As the rags are poor conductors of heat it is retained until sufficient heat accumulates to produce a *flame*. Oily rags should be kept in *metal* containers.

The gas in soda water is *carbon dioxide*. An acid like lemon juice in contact with baking soda will release the gas *carbon dioxide*. Baking soda will liberate *carbon dioxide* bubbles when mixed with tomato juice. The stomach manufactures hydrochloric acid. Too much of this acid causes "heart burn." Soda mints are compressed *baking soda*. This substance mixes with the *acid*, producing *carbon dioxide*. (In this process the acid is destroyed and pain relieved.)

In the presence of carbon dioxide *lime-water* turns "milky."

Carbon dioxide is found in exhaled *air*, gases from a *fire*; also in gas from a mixture of *baking soda* and an acid. Marble will give off *carbon dioxide* in the presence of an acid.

Chemical fire extinguishers of the carbon dioxide-forming type are operated by *inverting* them. Inverting a fire extinguisher causes the acid to mix with the *baking soda* in it. This forms *carbon dioxide* gas in the fire extinguisher, which forces the *contents* out violently. Water and carbon dioxide smother the *fire*.

UNIT IV

HOW HEAT CHANGES SUBSTANCES

GENERAL OBJECTIVES

The realization that:

Heat Changes Many Substances About Us

Emphasis is placed upon the use we make of this fact in the environment.

For example, the part played by heat in our use of paraffine, solders, and fuse wires; withdrawal of heat from foods in the refrigerator; the making of ice cream.

The importance of the phenomena of contraction, expansion, evaporation and condensation in every-day life. For example, the use of the thermometer; the circulation of air in refrigerators; water vapor in the air.

SPECIFIC OBJECTIVES	PROBLEMS FOR EXPERIMENT	DESIRABLE OUTCOMES
The Effect of Heat Upon Substances		
Expansion and Contraction Solids	1. Why are expansion joints provided in cement roads and pavements? (group experiment)	Knowledge: 1. Heat causes expansion
Liquids	2. What happens to liquids when they are heated? (group experiment) 2a. Why is salt used with ice in freezing ice cream? 2b. In the cooking of foods is gentle boiling as effective as brisk boiling? (group experiment)	2. Continued application of heat changes solids to liquids and then to gases. 3. Withdrawal of heat reverses the change of state and causes contraction.
Gases	3. Will air occupy the same amount of space when heated as when cool? 3a. How does the cold air circulate in the refrigerator?	
Evaporation	4. What makes water go into the air?	4 Heat is related to evaporation and condensation.
Condensation	5. How can we get water out of the air?	
Change of state	6. What becomes of ice in the refrigerator?	

NOTES ON EXPERIMENTS

Experiment 1 can be shown by heating a wire supporting a suspended weight and observing the elongation that takes place in the wire. **Experiment 2** can be shown by heating water in a flask filled with ink-colored water, having a glass tube inserted in a one-hole stopper and observing the rise of the water. **Experiment 2-a** consists of placing a thermometer in a beaker of ice and noting fall of temperature after adding salt. **Experiment 2-b** consists of comparing temperatures of rapid and gentle boiling. **Experiment 3** can be performed by placing the end of glass tubing which is inserted in a one-hole stopper in a Florence flask in a beaker of water colored with potassium permanganate; heat the flask and observe what happens when the flask cools. **Experiment 4** can be performed by observing evaporation from a small amount of boiling water. **Experiment 5** can be performed by observing water collecting on a beaker containing ice. **Experiment 6** can be performed by experiments with ice, paraffin, and solder showing the change from solids to liquids and gases.

DEVELOPMENTS

Experiment 1: (1) How is the knowledge gained in this experiment applied to the construction of the following:

railroad tracks, heavy artillery in the army and navy; pipes in steam and hot water heating systems; tires on wheels; rigid bridges of steel; poles for supporting overhead wires; clock pendulums? (2) Why do pipes crackle when steam is turned into them? (3) What is an expansion joint? (4) Why does a cold, thick glass tumbler break when hot water is poured into it? (5) What makes paper curl when it burns? (6) How does a thermostat work? (7) Examine the back of a watch and find the escapement wheel. How many compound bars can you find in its construction? (8) Make a diagrammatic sketch of the wheel showing how the rims are attached. Read the description and study the pictures in your textbook to aid you. (9) Explain how the compound bar construction in the watch helps to keep constant time in hot and cold weather. (10) Does a substance weigh more or contain any more material when expanded than when in a contracted condition?

Experiments 2, 2-a and 2-b: (1) Why does water heating in a full pan overflow? (2) What are the causes of ocean currents? (3) What substances are used in thermometers? (4) What is a centigrade thermometer? (5) What other kinds of thermometers do you know about? (6) How does a clinical thermometer work? (7) Why is

salt used upon ice covered pavements? (8) What is the principle behind anti-freezing mixtures used in automobile radiators? (9) When boiling foods how can we get the most efficiency out of a gas range burner? (10) When cooking potatoes are we trying to keep them very hot or are we trying to boil the water away from them? (11) Which are we trying to do in making candy, to keep the sugar very hot or to boil the water away from it?

Experiments 3 and 3-a: (1) How does expansion and contraction of gases operate in nature? (2) What illustrations of the expansion of gases can you name about your home? (3) What makes the lid of a boiling tea kettle rattle?

Experiment 4: (1) What causes pavements to "dry" after a rain? (2) All substances do not evaporate with equal speed. Give illustrations. (3) What illustrations of evaporation can you give about your home? (4) What would be some serious consequences to us in our everyday life if evaporation ceased to take place?

Experiment 5: (1) In what way is the principle of condensation employed in nature? (2) Does your breath contain water vapor? (3) How would you find out? (4) What illustrations of condensation can you name?

Experiment 6: (1) What substances are used in making electric fuse wire? (2) What quality must be considered in selecting materials for making fuses? (3) Make a list of the differences in shape, relative temperature, and visibility in substance when a solid, a liquid, and a gas. (4) What are some industries that depend upon the change of state? (5) What illustrations of change of state occur in

nature? (6) How does the knowledge gained in these experiments explain the use of a warm iron and a blotter in removing candle grease from clothing? (7) Name three substances that are usually solids at ordinary temperatures? Three substances that are liquids? Three that are gases?

SUMMARY

The process of making a substance take up more *space* without increasing its *weight* or its *material* is called *expansion*.

The process of making a substance take up less *space* without decreasing its *weight* or its *material* is called *contraction*.

Heating makes substances *expand*. Chilling makes substances *contract*.

Evaporation is the process of changing a substance to a *gas* or *vapor*.

Condensation is the process of changing a *gas* or vapor to a *liquid* by chilling the *gas*.

A solid has its own *shape*. It is *colder* than the liquid state of the same substance. It is *always* visible.

A liquid does not retain its own *shape*, but takes the *shape* of its container. It is *warmer* than the solid state of the same substance. It is *always* visible.

A gas or vapor does not retain its own *shape*, but takes the *shape* of its container. It is *warmer* than the liquid state of the same substance. It is often not *visible*.

UNIT V

WHAT THE SKY GIVES US

GENERAL OBJECTIVES

A. Man is Dependent on the Heavenly Bodies

The objectives are

- 1. To show that the sun is our source of light and color, heat and energy, and that the movements of the earth and moon give us our divisions of time.
- 2. To discourage belief in superstitions advanced by astrologers.

B. The Study of the Stars and Planets as Worthwhile Use of Leisure Time.

The object is to help the pupil appreciate the beauty of the stars and our solar system.

SPECIFIC OBJECTIVES	PROBLEMS FOR EXPERIMENT	DESIRABLE OUTCOMES
Some Knowledge of the Stars	1. Where is the North Star? 2. How are the stars arranged in the sky?	Ability to find some star groups Conviction that stars and planets do not control one's destiny
Movements of the Heavenly Bodies Result in Time units	3. How does the sun mark the time? (teacher experiment)	Realization that heavenly bodies move Knowledge: 1. The motions of the earth and moon govern our year, month, and day.
Eclipses	4. What causes eclipses of the moon and the sun? (group experiment)	2. Motions of the earth and moon produce eclipses and the moon's phases.
Light from the Moon	4.a Why does the moon have different shapes? (group experiment)	
The Sun Directly Benefits Us by Giving Us Light	5. How does light come to us?	Appreciation of the fact that: 1. The sun is the source of light and color, heat and energy.
Color	5.a What are the colors in sunlight?	2. The beauty and great variety of color in nature are revealed by sunlight.
Heat and Energy	6. Is sunlight hot? (class experiment)	

NOTES ON EXPERIMENTS

Experiment 1 can be performed at home, the pupils having been previously given specific directions for observance. Experiment 2 can also be performed in the same way; limit the assignment to the more conspicuous constellation such as Orion and Cassiopeia. Experiment 3 can be performed by using the following apparatus and following these directions: 1—Apparatus: Globe; flashlight; burette clamp and iron support to hold the flashlight; pencil or straight stick mounted on a cork or spool; piece of white paper. 2—Directions and observations: (a) Set the stick in the sunlight in such a way that its shadow will fall on the white paper. With a pencil draw a line on the paper to mark the position of the shadow. Indicate on it the time by the clock. Fifteen minutes later mark the shadow again. Has the shadow moved? If so, which way? You have just illustrated the method of telling time by a sundial. Set up the apparatus as shown in figure 6 and darken the room as much as possible. (b) Note how much of the globe is lighted by the flashlight (the sun) at one time. Does the light reach beyond the north pole? Beyond the south pole? Find your community and place X over it with white chalk. Turn the globe so that your community is on the side 90 degrees to the left of the sun as you look from the globe toward the sun. This is the situation at sunrise. Slowly rotate the globe from right to left ¼ turn. Note the position of the sun with rela-

tion to your community. This is the situation at noon. Slowly rotate the globe from right to left another quarter turn. Note the position of the sun with relation to your community. This is the situation at sunset. Slowly rotate the globe from right to left ½ turn. What part of the day does this situation represent? (c) Record your observations as follows:

Time of Day	Position of the Sun with relation to your community
Sunrise:	
Noon:	
Sunset:	
Night:	

Experiment 4 can be performed by using the following apparatus and following these directions: 1—Apparatus: Small, white ball to represent the moon; indoor baseball to represent the earth; flashlight to represent the sun; 2 burette clamps; 2 iron supports. 2—Directions and observations: By means of the burette clamps and supports arrange the flashlight and the small ball as shown in figure 7. Set the apparatus at such an angle that the class can clearly see the shadow appear upon the "moon" when the eclipse takes place. Darken the room as much as possible. (a) Pass the earth suspended by a string slowly between the sun and the moon. Note what happens to the light on the moon. This is what

occurs during a total eclipse of the moon. (b) Move the earth so as to cause a shadow to appear on the edge of the moon as the earth crosses the face of the moon. This is what occurs during a partial eclipse. In both operations note the shape of the shadow. Compare the shape of the shadow with the shape of the earth which made the shadow. (c) Hold the earth in a line with the sun and have someone pass the moon slowly between the sun and the earth. Note what happens and what body now casts the shadow. This is what occurs during an eclipse of the sun. **Experiment 4-a** can be demonstrated by having one pupil, holding a tennis ball

to represent the moon in outstretched hand, pass in a circle around the class who represent the earth. By observing the shape of the illuminated part of the tennis ball, the different phases of the moon can be noted. **Experiment 5** can be performed by observing the shadow of an object thrown on the floor and by observing dust particles in the air. **Experiment 5-a** may be performed by having pupils observe the spectrum or color band formed when a triangular glass prism is held in a beam of sunlight. **Experiment 6** can be performed by using a reading glass to concentrate heat rays and observing temperature changes.

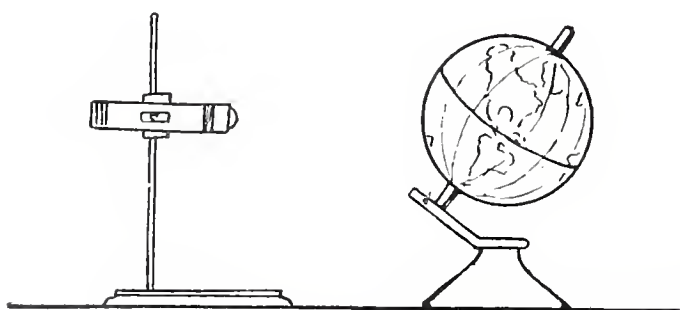


Figure 6

DEVELOPMENTS

Experiment 1: (1) Why is the North Star so named? (2) Of what important use is it to mariners? Hunters and campers often use the Great Dipper as a clock. (3) Explain how this is possible. (4) Find out what name is given to a group of stars like the Dipper.

Experiment 2: (1) In what are the stars like our sun? (2) Why do the stars appear so very much smaller than our sun? (3) What name is given to scientists who study the heavens and the stars? (4) How did star groups like Orion and Cassiopeia get their names? Be able to tell one of these stories. (5) What is the difference between astrology and astronomy? (6) Which one has to do with superstition? (7) Do stars really have anything to do with one's fate and destiny?

Experiment 3: (1) Does the sun really rise, move across the heavens and set? Explain. (2) Does our earth have any motion other than its own turning? (3) What fact determines the length of our year? (4) What fact determines the number of hours of daylight and darkness for each day? (5) By studying an almanac find out on what date we have the longest period of daylight and the shortest period of darkness; on what date the reverse is true; whether we ever have days when the periods of daylight and darkness are equal. (6) People did not always tell time from clocks. What were some early methods?

Experiments 4 and 4-a: The moon, called "Luna" by the ancients, was thought to cause people to become lunatics. (1) Is this a superstition or a true scientific fact? (2) What important scientific effect does the moon help to cause on the earth? (3) Does the moon travel around the earth or around the sun? (4) Will it move therefore with the stars or across the stars? (5) What are planets? (6) Is the earth a planet? (7) How could you tell a planet from a star? (8) What planets are most noticeable as "evening stars"? (9) What shape are the planets? (10) How does the eclipse of the "moon" in your experiment offer proof that the earth is round? (11) Does the moon shine by its own light? (12) What does the experiment show as to this? (13) With reference to the moon, what is really meant by First Quarter; Full Moon; Last Quarter; New Moon; Dark of the Moon? (14) How long does it take for the moon to pass from new moon to new moon? (15) If the moon does not really change its shape, to what fact are the apparent changes due? (16) Why

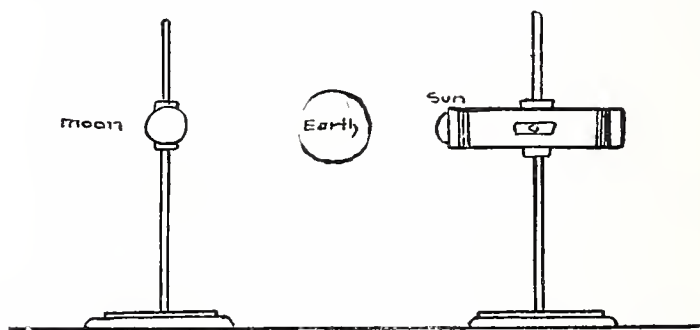


Figure 7

are the new or crescent moon points always turned away from the sun? (17) Do we ever see the entire moon?

Experiments 5 and 5-a: (1) What name is applied to bodies which give out light of themselves? Give an illustration. (2) What name is applied to bodies which do not give out light of themselves? Give an illustration. (3) Do light rays ever bring us heat? (4) Which travels faster—light or sound? (5) How long would it take light to go once around the earth at the equator? (6) What has the fact that light travels in straight lines to do with forming shadows? (7) What is a rainbow? (8) What acts in place of the glass prism to form the rainbow? (9) Why do objects often have a different color under artificial light than they have in the sunlight? (10) Do objects really have color in themselves? (11) What has occurred when we say an object has a "red" color? (12) Under what conditions will an object be "white"? (13) What is a "black" substance?

Experiment 6: (1) What kind of substances will change light rays to heat rays—those which absorb light rays or those which reflect them? (2) Why are green houses or hot houses often termed "traps" for colored sunlight. (3) Why do we wear light colored fabrics in summer and dark colored fabrics in winter?

SUMMARY

The North Star is the star about which the *Great Dipper* seems to turn. The North Star can be found by sighting along the *Pointers* of the *Great Dipper*.

The North Star indicates the direction *north* on a clear night. It is also used by mariners on clear nights to find their *latitude*.

Stars are great *suns*. They are enormously larger than our *sun* but appear very small because they are so far away.

Stars have nothing to do with one's *fate* or *destiny*. Persons who pretend to predict one's fortune from the stars are called *astrologers*; only savages and superstitious people listen to them. Scientists who study the laws of Nature which govern the sky and show its true relation to our own world are called *astronomers*.

The earth turns upon its *axis* once every 24 hours. This *motion* causes day and night. Day and night are not of

equal length in Pennsylvania throughout the year. On June 21 we have the *longest* period of daylight and on December 21 we have the *shortest* period of daylight that we get during the whole year.

The earth travels around the *sun* once every $365\frac{1}{4}$ days. This journey measures 1 year of time.

An eclipse of the moon occurs when the *moon* moves into the *earth's* shadow.

An eclipse of the sun occurs when the *earth* moves into the *moon's* shadow.

The moon travels around the *earth*. The earth and other bodies called *planets* constantly travel around the sun, each in its own definite path. Planets can be distinguished from stars because they do not *twinkle* and because they seem to move across the *stars*.

The sun constantly lights exactly half of the moon. The *phases* of the moon are names for 5 stages in its journey around the earth. In each stage except the last we can see a portion of the lighted side of the moon. At the phase we call the "dark of the moon" no part of that side is visible, for it is turned *away* from us as the moon is then between *us* and the *sun*. The *new* moon occurs when we can see only the edge of the lighted half; the *full* moon occurs when we can see all of it; the quarters occur when

we can see only half of it; the *first* quarter as the brighter side is coming more and more into view; and the *last* quarter as it is passing out of our view.

The moon gives no light of itself but *reflects* the *sunlight* shining upon it. We see and receive light from that half of the moon's surface that is turned toward the *sun*.

Light comes to us in *straight* lines. A *luminous* body gives out light of itself. A *non-luminous* body reflects light from some *luminous* body.

Light is the swiftest traveller, going at a speed of 186,000 miles per *second*.

White light, is a blending of 7 colors. These 7 colors are *red, orange, yellow, green, blue, indigo, violet*.

No object has color. Color comes from the *sun*. The effect of the object on the reflected *sunlight* causes its particular color.

The sun's rays themselves are not hot. Sun rays become heat rays only when they are *absorbed* by substances.

Objects of a *dark* color absorb most sun rays and so become heated. Objects of a *light* color reflect or ward off the sun's rays and so remain cooler. The *dark* soil in the "hot house" absorbs the sun's rays and retains the heat.

UNIT VI

MAGNETISM AND ELECTRICITY

GENERAL OBJECTIVES

A. Magnetism

The objective is to show the nature of magnetism in iron and steel.

B. The Usefulness of Electricity in Our Homes

The objective here is to show how electricity produces heat and light in electrical appliances.

SPECIFIC OBJECTIVES	PROBLEMS FOR EXPERIMENT	DESIRABLE OUTCOMES
The Behavior of Magnets	1. What is a magnet?	Knowledge:
Magnets and Magnetism	2. What are the poles of a magnet and how do they behave? (group experiment).	1. Of the laws of polarity.
	2a. How can we make magnetic influence visible? (group experiment).	2. That proper application of these laws will induce motion in the armatures of magnetic machines.
	3. What is an electromagnet? (class experiment).	
	3a. How can I produce an electric current at home? (group experiment).	
Useful Electricity	4. How does electricity produce heat? (class experiment).	3. That introducing resistance into an electric circuit always produces heat and in an electric bulb it also produces light.
Producing Heat and Light	5. How do we use the electric meter to make up an "electric light bill"?	Ability to compute a bill for electricity consumed.
Electric Bills		

NOTES ON EXPERIMENTS

Experiment 1 may consist of magnetizing a needle and also showing that certain other metals will not become magnetized. **Experiment 2** should show how a magnet behaves when suspended, figure 8. **Experiment 2-a** iron filings should be used to show the visible influences of magnetic ways. **Experiment 3** can be performed by making a simple electromagnet. **Experiment 3-a** should show how to make a simple electric current at home by the use of a wet battery. **Experiment 4** can be performed by using the materials indicated in figure 9. **Experiment 5** can be performed by having pupils read an electric meter at home.

DEVELOPMENTS

Experiment 1: (1) How are large magnets magnetized? (2) How did the ancients learn about magnets? (3) What is a "lodestone"? (4) What does "lode" mean? (5) How will a lodestone show a way or path? (6) What is a compass?

Experiments 2 and 2-a: (1) Why does a compass needle point generally north and south? (2) Could a machine be made to turn by magnetism? (3) Magnetic influence does not pass through soft iron. How would you prove this? (4) How is this fact helpful in building electrical instruments? (5) The mariner's compass does not point

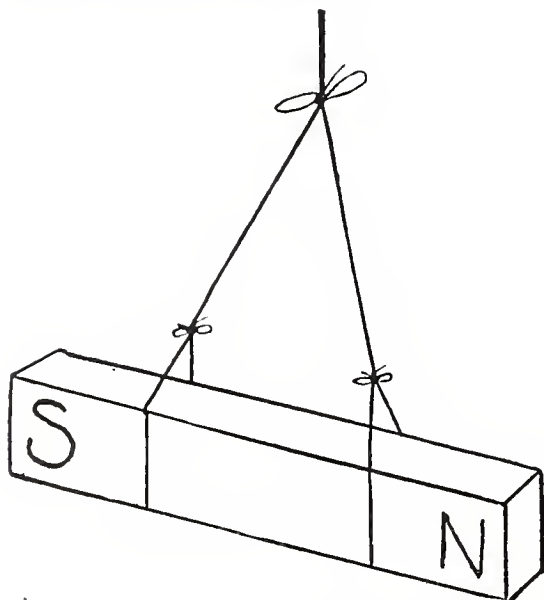


Figure 8

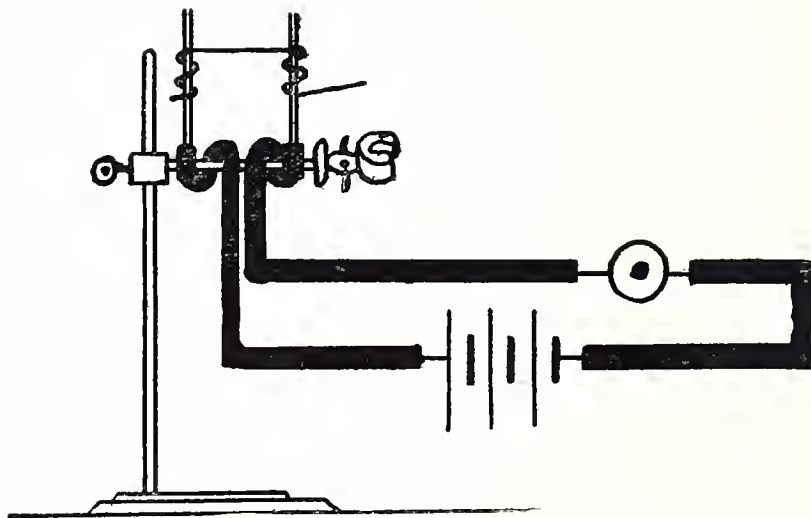


Figure 9

true North. Why? (6) How does a cargo of iron affect the compass? (7) When a ship is carrying a cargo of iron, how is the compass connected?

Experiments 3 and 3-a: (1) What is the difference between a permanent magnet and an electro-magnet? (2) How are magnets used in machines? (3) Describe an electric crane. (4) What is an armature? (5) What is a wet cell? (6) What is a dry cell? (7) Is a dry cell really dry? (8) What common sources of electricity can you name? (9) Why is lightning not used as a commercial source of electricity?

Experiment 4: (1) Why was the heat more intense in the operation using the thin wire than when the two heavy wires were touched? (2) How does an electric toaster work? (3) The same principle is involved in the electric flatiron. (4) How many other examples of this kind of electric heat can you name? (5) What is nichrome? (6) How is light produced by electricity? (7) What is the use of the vacuum around the filament in an electric bulb?

Experiment 5: (1) From your last bill get the numbers on the dials at that time and then find out how much electricity, gas, or water you have used since. (2) At the rates given on the bills compute the cost.

SUMMARY

A magnet is a piece of *iron* or *steel* that is able to attract another piece of *iron* or *steel*.

One magnet can make another magnet of a non-magnetic piece of *iron* or *steel* by coming in *contact* with it.

The ends of a magnetized bar are called *poles*. Poles of a magnet are *opposite* in their influence upon each other.

"Unlike poles" *attract* each other. "Like" poles *repel* each other.

A wire carrying *current* is surrounded by a magnetic field. This wire sets up magnetism in an iron core that it may surround, but only when current is *passing* through the wire.

The parts of a magnetic machine that are put into motion are called armatures.

Heat from electricity is due to *resistance*. One way to get *resistance* in an electric circuit is by reducing the *diameter* of the conducting wire. Electric heating devices are operated by the heating of wire due to *resistance*. Some conductors are better than others for offering *resistance*. A very good resisting conductor is *nichrome* because it will stand considerable heat without disintegration and thus breaking the circuit.

Light will be produced by electricity when the conductor offers sufficient *resistance* to be *heated* until it *glows* brightly.

Taking the lowest number nearest the *hand* on each dial and arranging them in a *row* forms the meter reading. By subtracting a reading of *former* date from a reading of *recent* date, the *difference* is the amount of current used. The amount of the bill is computed on the basis of this *quantity*.

UNIT VII

MAKING USE OF WATER

GENERAL OBJECTIVES

The Usefulness of Water in Everyday Life

The objectives are:

1. To show that water becomes a heating agent through the processes of expansion, contraction, and convection.
2. To demonstrate how evaporation causes water to serve as a cooling agent.
3. To know that the solvent power of water makes it a cleaning agent.
4. To realize that clean water may not be pure water.
5. To prove that water pressure is adaptable in the production of power but restricts the depth range of the submarine.

SPECIFIC OBJECTIVES	PROBLEMS FOR EXPERIMENT	DESIRABLE OUTCOMES
How Water Helps Us		Knowledge:
Water Warms Us	1. How does water make us warm? (teacher experiment).	1. Circulation of water is due to expansion and contraction; that it carries heat by convection.
Water Cools Us	2. How does water make us cool? (group experiment).	2. Evaporation produces a cooling effect.
	2a. How is ice made in summer? (teacher experiment).	
Water Cleans Us	3. When will water make us clean? (group experiment).	3. Only water that dissolves soap becomes a dirt remover. Ability to make hard water soft.
Guarding the Water Supply		
Clear Water	4. How can we make dirty water clean?	
Pure Water	5. What is distilled water?	Realization that clean water may not be pure water.
Care of Plumbing	5a. Where should we look for trouble in the lavatory or kitchen plumbing? (class experiment).	Ability to diagnose and prevent leaking faucets and stopped-up drains.
Using Water Pressure		Knowledge:
Transportation	6. How deep can a submarine go?	1. Water pressure increases with depth.
Power	7. What is "white coal"? (teacher experiment).	2. This principle must be observed when building submarines and power dams

NOTES ON EXPERIMENTS

Experiment 1 can be performed by using the apparatus listed in figure 10 to show how water can be made to circulate. **Experiments 2 and 2-a** can be performed by showing how evaporation cools materials. In connection with this experiment the making of ice should be explained. **Experiment 3** can be performed by showing the effect of soap in rain water, salt water, and lime water and the softening effects of washing soda. **Experiment 4** can be performed by using filter paper and powdered bone charcoal to show how water can be clarified. **Experiment 5** can be performed by using salt water in the simple apparatus in figure 11 to distill water. **Experiment 5-a** requires the examination of the construction of a faucet and a V shaped water trap, figure 12. **Experiment 6** can be performed by using the apparatus in figure 13 to indicate the influence of the depth of water on the column of colored water in the U-tube. **Experiment 7** can be performed by showing how water can be used to produce power.

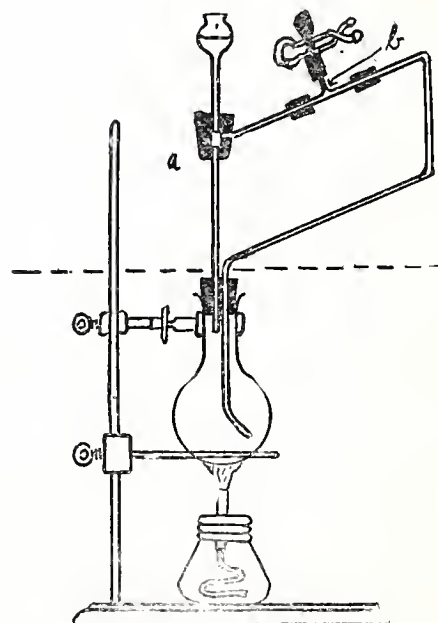


Figure 10

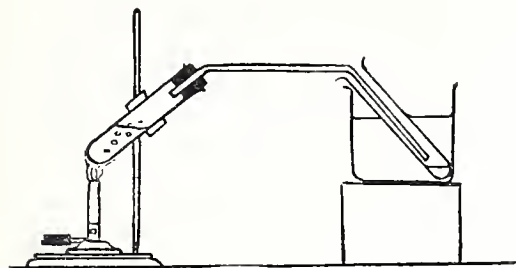


Figure 11

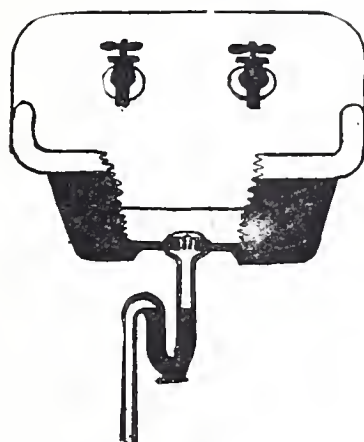


Figure 12

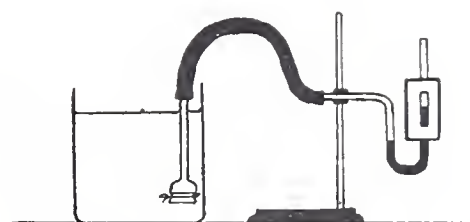


Figure 13

DEVELOPMENTS

Experiment 1: (1) How does the hot water heating system in a private home work? Make a simple drawing. (2) What does the thistle tube used in the experiment correspond to in your drawing? (3) Which part corresponds to the "boiler"? (4) What is the part of your home heating plant that corresponds to the pinch-cock? (5) Which part of the laboratory apparatus corresponds to a radiator? (6) What does dotted line of the drawing correspond to in your heating system at home? (7) What does convection mean in connection with the transfer of heat? (8) How does the radiator of an automobile operate so as to cool the engine? (9) The movement of water by heating is caused by expansion. (10) What explanation does your textbook give about expansion? (11) What are the causes of ocean currents?

Experiments 2 and 2-a: (1) Why do we wet our sidewalks in summer? (2) Why should we keep out of a draft when we are wet with perspiration? (3) How can cool water be obtained in desert regions? (4) What is a "wet and dry bulb" thermometer set? (5) Why will bathing a sick person with alcohol reduce the temperature? (6) Construct a refrigerator from a wooden frame work, surrounded by cloth which can be kept wet by having its lower edges in water. Take a thermometer reading inside the box before and after wetting the cloth. (7) Compressing a gas causes it to change to a liquid. Releasing the pressure causes it to change back to a gas. How is this fact made use of in an ice-making machine? Make a drawing to show this use.

Experiment 3: (1) What is soft water? (2) What is temporarily hard water? (3) What is permanently hard water? (4) What are water softeners? (5) Why do country people save rain water for washing? (6) What kind of water do we have delivered to us in our homes? (7) What is hard water soap?

Experiment 4: (1) How is water filtered in nature? (2) Describe the method in use in your community for making water clear.

Experiments 5 and 5-a: (1) What is a distillate? (2) Why is the ocean salty? (3) Why is rain water soft? (4) How can metered water be saved in factories where great quantities of water are used in the operation of their steam engines? (5) How many uses of distilled water can you mention? (6) What commercial products do you know that are prepared through the process of distillation? (7) Are these products always distillates? (8) What makes a faucet "hum" or "sing" at times? (9) What is a "gate" valve? (10) Before correcting a leaking faucet the water supply must be shut off. Just where in your house can this be done? (11) Compare the drawing of the sink with the drain pipe under your kitchen sink. Where does the water lie in the trap? (12) Why is the trap placed at the bottom of the loop in the sink drain pipe? (13) How many other traps can you find in your home? (14) How is a trap opened? (15) What would

happen to such traps in an empty house in winter time? (16) What should be done about this? (17) Why is it necessary to have the loop in drain and sewer filled with water?

Experiment 6: (1) What is a caisson? (2) Why do divers have steel reinforced air lines leading to them? (3) What effect does lessening the pressure have upon deep sea fishes when they rise toward the surface at night for food?

Experiment 7: (1) What is a power dam? (2) Why should they be high? (3) Name several great power dams. (4) Where is the Conowingo; the Pymatuning? (5) How do we get the term "white coal"? (6) What countries will have the best manufacturing facilities in the coming years? (7) What was the old style of water power? (8) What is an over-shot wheel? (9) What is a water turbine engine? (10) Of what other use of great dams can you think?

SUMMARY

Heat makes water and other liquids *expand* or take up more *space*. Hence the heated water circulates.

When particles of water are heated they *circulate* and carry the heat with them. This method of transferring heat is called *convection*.

The operation of a hot water heating system depends on *expansion* and *convection*.

When a liquid changes to a gas we call the process *evaporation*. Wherever evaporation takes place it always removes the *heat* from surrounding *areas*.

Evaporation of perspiration is nature's original *refrigerator*. Bathing reduces fever by *evaporation*. Wetting pavements in summer cools them, due to the resulting *evaporation*.

Ice machines, by changing liquids to gases, so *reduce* the temperature of the pipes in which this takes place, that these pipes in turn remove the *heat* from any surrounding water, thus producing *ice*.

Only water that dissolves *soap* becomes a dirt remover in washing. Rain water is *soft* water because it has no *minerals* dissolved in it. The test for soft water is the presence of *suds*, when soap is shaken or rubbed in it.

The test for hard water is a *scum* in the water and a few *suds*. This means that *minerals* are dissolved in it. Good softeners for hard water are *borax* or *washing soda*.

A filter removes *solid* matter from water and other liquids. Solid matter is *undissolved* matter in liquids.

In nature, water is cleared by slowly *filtering* through the *soil*.

Boiling water and then condensing the gas to water again by cooling is called water *distillation*. Steam is a *gas* which on cooling *condenses* to *water*. The condensed liquid from a still is called the *distillate*. Solids which dissolve in water do not change to *steam* when the solution is boiled, and so *remain* after the steam escapes.

A leaky faucet is due to a *worn* washer. The washer wears away by *grinding* due to opening and closing. Foreign matter in the faucet thus becomes imbedded in the *washer* and cuts "leak grooves." The singing of a faucet is due to a *loose* washer, which is set into vibration by the *water*.

The trap is to keep out *gas* from the sewer connections.

When a drain is stopped up the first place to look is in the *trap*. Traps have special openings for the *removal* of *solid* matter. Traps should be *drained* in empty houses so that water in them cannot freeze and break the pipe.

The deeper we go under water the greater becomes the *pressure* exerted upon things in it. The pressure is due to the *weight* of the water above. The depth under water to which a submarine boat can go depends upon the strength of its *walls*. Submarines must be constructed so as to *withstand* the *pressure* of the *water*.

In a dam *deep* water produces *pressure* which increases toward the bottom of the dam. This pressure is used to *turn* turbine engines and so to give power. Water power so obtained is called "*white coal*."

UNIT VIII

FLOWERS AND PLANTS

GENERAL OBJECTIVES

Importance of Plants and Plant Products

The objective is to appreciate the use of seeds, roots, stems, and leaves in the solution of the food problem of the living world, including man.

SPECIFIC OBJECTIVES

Providing Food for Living Things

The Work of Seeds

The Work of Roots

The Work of Stems

The Work of Leaves

Useful Trees

PROBLEMS FOR EXPERIMENT

- 1. What is inside of a plant seed?
- 2. How do seeds grow into plants? (class experiment)
- 3. Why do plant roots grow down into the soil? (class experiment)
- 4. What does the stem do for the plant? (group experiment)
- 5. Where do plants make food? (teacher experiment)
- 6. How can I know the neighborhood trees?

DESIRABLE OUTCOMES

- Knowledge:
- 1. Of the 4 parts of a seed and their functions in the developing new plant.
 - 2. That the root is a supporting and food collecting structure.
 - 3. That the stem carries and distributes food and water and supports the leaves and flowers.
 - 4. That the leaf is the food factory of a plant.
- Appreciation of the dependence of all animal life, including man, upon the plant world for food.
- Correlation of this unit with Arbor Day.

NOTES ON EXPERIMENTS

Experiment 1 may consist of the examination of the inside of a soaked lima bean seed. Experiment 2 can be carried out as indicated in figure 14. Experiment 3 can be performed by observing a tumbler of growing bean plants. Experiment 4 can be performed by coloring water and placing stalks of celery containing a few leaves in this and observing how the water rises in the stem. Experiment 5 can be performed by using the following apparatus and following these directions: 1—Apparatus: Growing potted plant, such as a geranium, two 3/4 inch square pieces of cardboard, paper clip, beaker 1/2 full of denatured alcohol, dilute iodine solution, beaker, water. 2—Directions and observations: Select a large healthy leaf and without detaching it from the plant, fasten the squares on it as shown in figure 15. Place the plant so that the leaf is in strong sunlight. On the second day, after the plant has been at least an hour in the sunlight, pick off the leaf and remove the square. (a) Examine the leaf. Do you note any change in the part of the leaf that was covered by the squares? (b) Soak the leaf first in hot water for a few minutes and then in alcohol for a day or so until the color is removed. Wash the leaf in warm water and drain it. Examine it, particularly the spot which was covered by the squares. (c) Put the leaf in the iodine solution for a few minutes. Place it on the blotting



Figure 14

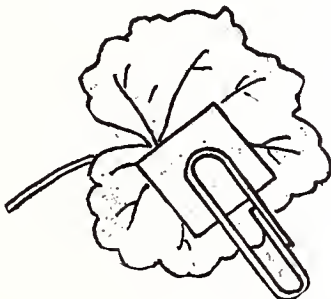


Figure 15

paper and describe what has happened. Iodine turns blue in the presence of starch, a food manufactured by plants. Experiment 6 can be performed by observing leaves of the various trees in the neighborhood. See accompanying Plant Calendar.

PLANT CALENDAR

March and April

A. TREES

Maple : White
Red
Norway
Ash-leaved (Box Elder)
Sugar
Sycamore

Elm : White

Poplar : Carolina
Lombardy
Balsam

Oak : Pin
White
Black
Red

Magnolia : White
Pink
Dark Red

Red Bud or Judas

Sycamore or Button Ball

Fruit : Cherry
Pear
Plum
Peach
Apple

B. SHRUBS

Yellow Jasmine
Bush Honeysuckle
Japan Quince
Forsythia
Barberry

C. BULBS, ETC.

Swamp Cabbage
Snowdrop
Crocus
Scilla
Daffodil
Hyacinth
Tulip
Narcissus

D. HERBS

Dandelion
Violet
Spring Beauty
Bloodroot
Anemone

April 15 — June 15

A. TREES

Mulberry
Birch
Horse-chestnut
Ash
Dogwood
Catalpa
Ailanthus
Tulip

B. SHRUBS AND VINES

Wistaria
Ampelopsis
(Common Ivy)
Syringa
Spirea
Roses
Hydrangea
Weigelia
Azalia
Rhododendron

C. HERBS

Star of Bethlehem
Jack-in-the-Pulpit
May Apple
Iris
Crane's Bill
Buttercup
Columbine
Daisy
Clover

Note: This chart is included for reference. It is not to be made a required assignment for the pupils.

DEVELOPMENTS

Experiment 1: (1) Why does a seed need to absorb water before it can begin to grow? (2) What relation is a seed to a plant? (For what purpose are seeds produced?) Some plants can be started growing by planting some part other than seed. (3) What flowering plant is often grown this way indoors? (4) What part is planted?

Experiment 2: (1) What are the six parts of a green plant? (2) Which of these parts are provided for in the seed itself? (3) What are the four things plants require in order to grow? (4) All plants do not like to grow in the same kind of surroundings. Name one that lives in water; one that likes a very dry soil; one that lives in very shady places and is not a green plant.

Experiment 3: Soil holds in reserve the water that supplies the streams. (1) How do roots (particularly tree roots) aid in conserving our water supply? (2) Are plant roots ever made use of by man? Give examples.

Experiment 4: Some plant stems are composed of very rigid, woody material. (1) What does this characteristic enable the stem to do for the leaves and flowers? (2) Some plants use stems as climbers or clingers to hold them up. Give examples of this kind.

Experiment 5: (1) Under what conditions only can plants manufacture food materials in this way? (2) Suppose there were no green plants, what effect would it have on animal life? (3) Can animals make food materials in the way plants do?

Experiment 6: Besides adding beauty and giving shade, trees have other uses. (1) Name at least two trees whose wood is valuable. (2) About how old must a tree be before it is useful as lumber? (3) For what commercial use are the smaller spruce and hemlock trees valuable? (4) Name at least two trees whose bark is valuable. (5) Name at least two trees whose sap is useful. (6) Name trees whose fruits are wholesome. (7) Trees also conserve the water supply. (Review Experiment 3.)

SUMMARY

Seeds are portions of a *plant* which grow into plants *similar* to the parent.

A seed consists of a *radicle* and *plumule* surrounded by a *food* storehouse, the *cotyledons*, bound together by *skin*.

Green plants consist of *roots*, *stems*, *leaves*, *flowers*, *fruits*, and *seeds*.

Plants require *air*, *water* or *soil*, *sunlight*, and *warmth*.

Roots *anchor* the plant to the soil. Roots absorb from the *soil water* and dissolved *minerals* which the plant needs.

Soil acts like a *sponge*, holding soil water and allowing it to drain out very slowly. If plant roots did not hold the soil from being washed away, *rivers* would not be supplied and our *water* supply and *food* would fail.

Some roots are used by man. Examples: *carrots* and *turnips* are foods; *rhubarb* and *snakeroot* are medicines.

Stems have *tubes* running through them which carry *liquids* to various parts of the plant.

Stems support the *leaves*, *flowers* and *fruit* in the *air* and *sunlight*. Some do this by having a *rigid* stem (trees); some use *tendrils* (sweet peas); some *twine* the stem about a support (morning glory, lima beans).

Plants are able to make food in the leaves provided they are exposed to *sunlight*.

Animals can not manufacture their own *foods* but must obtain them from plants, directly or indirectly. If there were no plants, all animal life, including mankind, would *starve*.

All pupils should be able to recognize on sight the leaves of Carolina poplar, maple, buttonwood, elm, horse chestnut, catalpa.

Trees provide *shade*, add *beauty* to the landscape, and provide *homes* for many kinds of small *animals*. The wood of trees is used for *lumber*. Most trees must be from 50 to 75 years old before they are large enough to saw into lumber. Smaller *spruce* and *hemlock* trees are used for pulp, chemical wood, and Christmas decorations. These trees should be removed only when thinning methods are employed to reduce crowding and valueless trees in the wood lot. Cork is prepared from *bark* of the cork oak. A very useful medicine, called *quinine*, is produced from the bark of the cinchona trees which grow in South America. Maple trees yield *syrup* from their sap, pine tree sap gives *turpentine*. Cherries, peaches, apples are wholesome tree *fruits*. Trees conserve water supply by holding *soil* in place.

EIGHTH GRADE COURSE IN SCIENCE

UNIT I

PLANT PRODUCTS AND PENNSYLVANIA FORESTS

GENERAL OBJECTIVES

A. The Uses of Woods

1. There are many different woods with which we come in daily contact.
2. The importance of conservation of these woods. For example, observation revealed that the leg of a quartered oak chair in the classroom contained parts of 20 annual rings. Hence, it took 20 years for the growing tree to prepare the material used in this part of the chair. We are not studying cell structure here.

B. The Use of Forests

1. The usefulness and beauty of the forest and its use to us all in recreational opportunities for leisure time.
2. The conservation of soil and water supply.
3. The responsibility of the citizen and the Commonwealth in the care and proper use of forests.

SPECIFIC OBJECTIVES

PROBLEMS FOR EXPERIMENT

DESIRABLE OUTCOMES

PART I

Trees in Relation to Our Homes Wood as a Building Material

1. What is the inside of a tree like?
- 1a. How does a tree grow?
2. What is "quartered" oak? Why are table tops often "veneered"?
- 2a. What are "hardwoods" and "softwoods"?
3. What sorts of wood are used about our homes?

Films (See Appendix)

Knowledge:

1. Annual rings which are seen in the cross section of a stem show how many years wood has grown.
2. The beauty of wood depends upon whether it is plane sawed or quarter sawed.
3. Veneering is an economical way to use beautiful woods.

Other Tree Products

- *Gums, Resins, and Rubber
- *Cellulose
- *Distillation Products
- *Vegetable Oils
- *Films (See Appendix)

4. There are important by-products of wood.
- Appreciation of the fact that our best timber trees grow slowly, and hence should be protected against fire and careless cutting.

PART II

Trees in Our Neighborhood Neighborhood Trees and Their Care

4. What kinds of trees grow in my own home block?
 - **What is the Community Doing to Realize Penn's "Greene Country Towne"?
- Films (See Appendix)

Convictions:

1. Trees are desirable in streets and parks because of their shade and beauty.
 2. The beauty of a tree depends on intelligent care with respect to trimming and protection from insect pests.
- Appreciation of the significance of Arbor Day.

PART III

Forests in Relation to Conservation Nature's Water Reservoir

5. What kinds of soil hold the most water? (Review 7th Grade Course, "The Earth's Crust," Experiment 6-a) (group experiment)
- 5a. What becomes of the leaves of our forest trees? (class experiment)
- 5b. How do roots prevent soil from washing away when it rains? (class experiment)

Appreciation of the fact that:

1. Trees regulate the water supply and enrich the soil.
2. Regulated cutting and reforestation will bring back and maintain our wood supply.
3. Forest fires, due to carelessness, are the greatest menace to forests.

Our Dwindling Wood Supply

- **The Abuse of Forests by Lumbering Companies and Christmas tree vendors
 - **Fire—The Red Menace of Our Forests
- Films (See Appendix)

*Museum Lessons
**Reports

PART IV

Recreation in the State Forests of Pennsylvania

Having a Good Time in the Forest

Forestry as a Vocation

6. Why do forests always feel cool and moist? (class experiment)

6a. How much water does a plant give to the air? (class experiment)

**Where Can I Build or Use a Summer Camp on State Lands?

**How to Travel Through the Forests.

**How to Stay Overnight in a Forest.

**How to Cook in the Forest.

**The Opportunities in Forestry.

**How to Become a Forester.

Films (See Appendix)

Knowledge of how to camp and hike through the forest with safety to ourselves and the forest.

Conviction that forestry is a worthwhile, interesting, and patriotic profession.

PART I—TREES IN RELATION TO OUR HOMES

EXPERIMENT 1

A. Problem

What is the inside of a tree like?

B. Experiment

1. Apparatus

Branch about 1 inch in diameter and 4 inches long of oak, maple, buttonwood, or other common tree; reading glass; sharp knife.

2. Directions and Observations

a. Examine the end of the branch and note the following: the bark, the annual rings, the medullary or pith rays. (See Figure 16.)

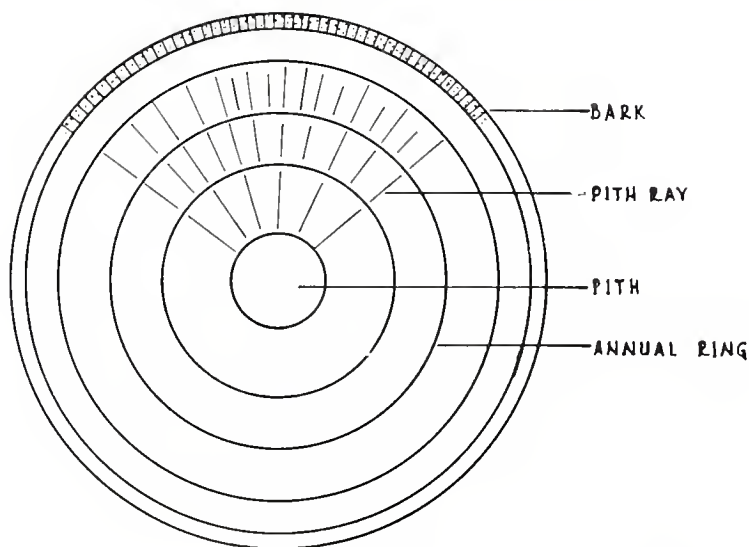


Figure 16

Between the bark and the wood is the growing layer called the *cambium*. Wood cells form on the inner side of this layer and bark on the outer side. It is from this growing layer that the ring of "new wood" is formed each season.

b. Count the annual rings. Each ring represents one year's growth.

c. With the reading glass try to see the fine openings of tube-like cells in the wood between the hard layers forming the annual rings. These tubes carry soil water from the roots to the leaves.

With the sharp knife make a cut across the branch one inch from the end and deep enough to reach the center of the branch. Now make a longitudinal cut through the center of the wood down to the cross cut. (See Figure 17.)

d. Note which cut required more effort: *across the grain* (the cross cut) or *with the grain* (the longitudinal cut, or "split").

e. Examine the longitudinal cut noting the following: bark, sapwood, heart-wood. In the inner layer of bark called the *bast* layer are tube-like cells which carry manufactured food materials from the leaves downward.

f. Note all the differences you can between the heart-wood and the sap-wood.

3. Conclusions

What parts make up the inside of a tree trunk or tree branch? How can you tell the age of a tree

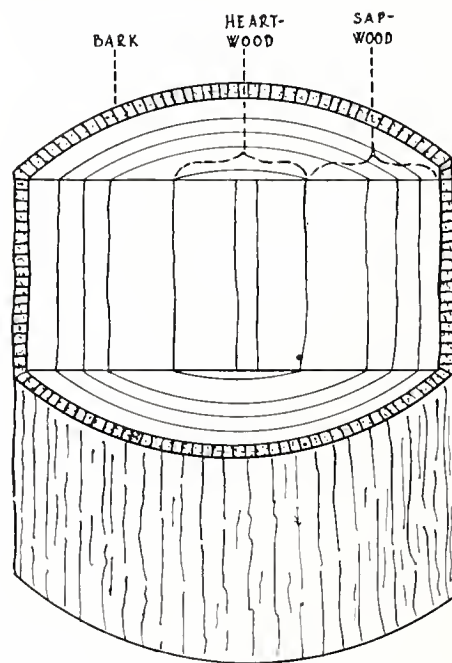


Figure 17

trunk or tree branch? Which is the older wood of a tree—the heart-wood or the sap-wood? What are the differences in appearance between wood cut "across the grain" and wood cut "with the grain"?

C. Development (after "Conclusions" of Experiment 1-a)

EXPERIMENT 1-A

A. Problem

How does a tree grow?

B. Experiment

1. Apparatus

An end twig, about 12 inches long, of a horse chestnut, maple, oak or other common tree; sharp knife; rule.

2. Directions and Observations

a. Measure from the bud end of the branch back to the first ring around the twig, which is the ring

**Lessons with material which may be purchased from the Philadelphia Commercial Museum, 34th and Spruce Streets, Philadelphia, Pa.

left by last year's bud scales, to find out how many inches the twig grew last season.

- b. Find other rings and discover how many years the twig has been growing.
- c. Make a cross section at the thickest part of the branch. Count the annual rings to see how that number compares with the age of the branch you found in "b."

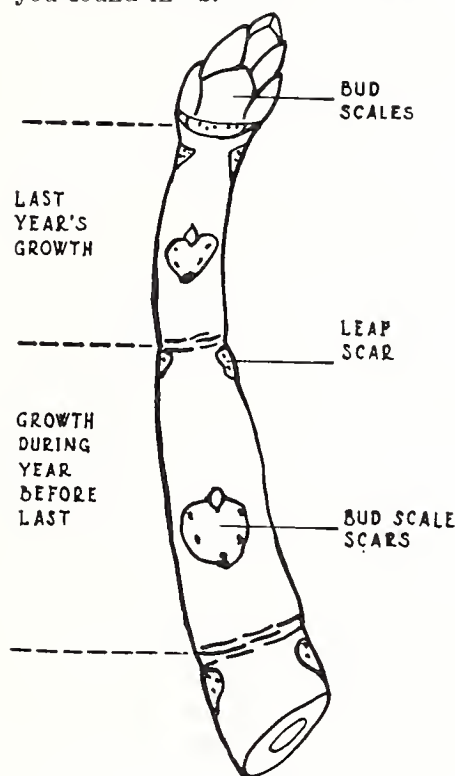


Figure 18

3. Conclusions

In answering the problem question explain which layer of wood is the oldest and where the new wood is formed in a tree.

C. Development—Experiments 1 and 1-a

After examining the stump of a California giant red-wood tree, its age was given at nearly 1000 years.

1. How was this determined?
2. Do all trees grow the same amount in a season?
3. Why is the bark on the trunk of a tree not as smooth as it is on the smaller branches?
4. In what direction does the bark crack? Why?
5. Does the bark increase in thickness as fast as the wood?
6. What causes a "knot" in wood?
7. What preparation do temperate zone trees make for winter? (Recall 7th Grade Course, "Exploring Nature," Experiment 5.)

EXPERIMENT 2

A. Problem

What is "quartered" oak?

B. Experiment

1. Apparatus

Small block of oak wood cut to show the cross section, the radial surface, and the tangential surface; diagrams.

2. Directions and observations

Examine carefully the drawing showing the 3 surfaces of a wood block.

- a. On the different surfaces of your oak block identify the medullary or pith rays, annual rings, and the tube-like cells (pores) of the annual rings.

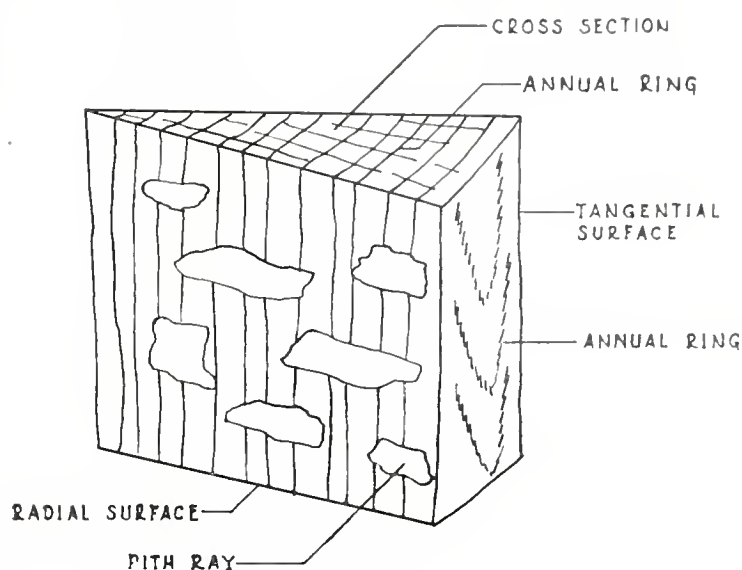


Figure 19

- b. Look at the tangential surface of your block noting what produces the "grain" of the wood.
- c. Look at the radial surface of your block noting what produces the straight grain and also the "silver grain" markings. This surface is exposed by "quarter" sawing the log.

Study the following diagram showing the two methods of sawing logs.

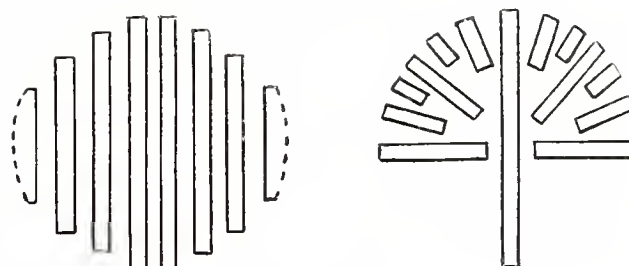


Figure 20

- d. With relation to the medullary rays how must a board be sawed in order to expose the "silver grain" of "quartered" lumber? Which of the two methods of sawing results in the least waste of lumber?

3. Conclusions

To obtain the greatest amount of "silver grain" surface on a board how must the log be sawed? What is the greatest objection to sawing lumber in this manner?

C. Development (after "Conclusions" of Experiment 2-b)

EXPERIMENT 2-A

A. Problem

Why are table tops often "veneered"? What are "hardwoods" and "softwoods"?

B. Experiment

1. Apparatus

The block of wood used in Experiment 2; teacher's desk; strip of "veneering" wood.

2. Directions and Observations

- a. Examine each surface of the wood block to determine which is most attractive in appearance.
- b. Examine each surface of the block to determine which would lend itself best to polishing.

- c. Observe the strip of "veneering" noting its thickness and its amount of flexibility.

d. Inspect the surfaces of the teacher's desk to determine which parts have been veneered.
3. Conclusions
- What are the advantages of veneering furniture? Why are the veneering layers made so thin?
- C. Development (after "Conclusions" of Experiment 2-b)

EXPERIMENT 2-B

- A. Problem
- What are "hardwoods" and "softwoods"?
- B. Experiment
1. Apparatus
- Leafy twigs from different trees including the evergreens.
2. Directions and observations
- Separate the twigs into two piles. In one place all those whose leaves are needle-like. These belong to the "softwood" trees. In the other pile place all the other twigs. These belong to the "hardwood" or broad-leaved trees.
- a. Identify the trees from which each twig was obtained. (Consult a "tree book" if necessary.) List your twigs according to the following chart:

"Softwood" Trees	"Hardwood" Trees

3. Conclusions
- How could you distinguish "hardwood" trees from "softwood" trees?
- C. Development—Experiments 2, 2-a, and 2-b
- (1) Why is oak practically the only wood that is "quartered"? (2) Why is "quarter sawed" lumber less likely to warp than ordinary lumber? (3) Why must lumber be "seasoned" before it is used? (4) What is meant by "kiln dried" lumber? (5) What woods are mostly used for veneering? (6) Curly walnut and "bird's-eye" maple are almost always used as veneering woods. Why? (7) Why do we not use pine as a veneer? (8) Why will properly veneered furniture "wear" better than furniture made from "straight" wood? (9) Are all "softwoods" really soft? (10) In building a frame house why are "softwoods" generally used for the exterior and "hardwoods" for the interior? (11) If wood is to be covered with paint is a "softwood" or a "hardwood" generally used?

EXPERIMENT 3

- A. Problem
- What sorts of wood are used about our homes?
- B. Experiment
1. Apparatus
- Furniture and other articles about the home or school made of wood.
2. Directions and observations
- Examine various pieces of furniture, the doors, the window frames, floor boards, etc., of your school room or the living room at home.
- a. As far as you can, identify the kinds of wood used. Note what surface is exposed (recall Experiment 2). Where the cross section is

visible determine how many years of growth are represented. Record your observations in a chart form as follows:

Article	Kind of wood	Type of wood surface exposed	Yrs. of growth represented

3. Conclusions
- What kinds of wood were mostly used for furniture? What kinds were employed in construction or ornamentation of the room observed?
- C. Development
- (1) Why is it unwise to choose very light or very heavy woods for furniture? (2) Why is "kiln dried" lumber best for interior finish? (3) What woods are considered most durable for use as roofing shingles and for fence posts? (4) What sort of wood is employed for making railroad ties? Why? (5) Why is hickory wood usually selected for making hammer and axe handles and for spokes of wheels? (6) Wood paving blocks are always laid with the cross section surface up. Why? (7) Are there any advantages of a wooden house over a brick house? (8) Can you give any disadvantages? (9) Why is wood of such great value for constructing buildings and furniture?

SUMMARY

- Wood as a Building Material
- The trunks of our common trees have the older and stronger *heartwood* near the center, then the newer *sap wood* next the *growing* layer, and then the *bark* outside. If the tree is cut across the *grain* each year's growth can be seen as an annual *ring*.
- Wood is beautiful because of its *grain*. To show the straight grain lumber must be *ordinary* sawed. To show the figure (silver grain) lumber must be *quarter* sawed, a most *wasteful* method of sawing.
- Wood of unusual beauty such as "bird's eye" *maple* is usually sawed into thin strips called *veneer* and glued over *cheaper* woods. Properly veneered furniture has added strength because the process makes it less liable to *warp* and *split*.
- Wood is a valuable construction material because it can be *split*, *sawed*, and *cut* easily and its pieces can be readily fastened together by *nails*, *screws*, and *glue*.
- Other Tree Products. (See also "Museum Lessons" on this topic in Appendix).
- True gums are *soluble* in water.
- Many substances are inaccurately called *gums*.
- Rubber is made from the "*milk*" of the rubber tree; maple syrup comes from the boiled *sap* of the maple tree; resinous *sap* from the southern *pine* produces turpentine.
- By distillation of waste wood, wood *alcohol* and acetic *acid* are obtained; by distillation of the leaves of a Japanese tree *camphor* is produced.
- From a solution of the bark of a Peruvian tree *quinine* is made.
- The bark of a Spanish oak gives us *cork*; from oak and hemlock bark we obtain *tan-bark* for curing leather.
- From the chips of softwoods and shredded corn stalks we obtain *woodpulp* and *cellulose* for making paper and artificial silk.

PART II—TREES IN OUR NEIGHBORHOOD

EXPERIMENT 4

A. Problem

What kinds of trees grow in my own home block?

B. Experiment

1. Apparatus

Leaves from neighborhood trees; notebook paper; pencil; rule.

2. Directions

a. Collect a leaf or make a drawing of a leaf found on each kind of tree on your home block. (Leaves should be laid flat between pages of your notebook as soon as collected.) From some source book such as a tree book or Scout Manual identify each.

b. On a page of your notebook draw a line representing the curb around your home block, to the scale of one inch to thirty paces. On this plan locate by dots the trees you find along the street and in yards.

c. In a table below your plan write the names of your trees and give each kind of tree a number. (Use the numbers from the accompanying list. If you find trees not named in this list write them at the bottom of your table and give them appropriate numbers.)

d. Place the proper number beside each dot on your plan.

3. Conclusions

How many trees did you find in your own home block? How many different kinds of trees were represented?

MOST COMMON SIDEWALK AND YARD TREES OF PENNSYLVANIA

1. Buttonwood	13. Horse-chestnut	27. Locust, white
2. Poplar,	14. Catalpa	28. Locust, honey
Carolina	15. Ailanthus	29. Walnut
3. Poplar,	16. Ash	30. Paulownia
Lombardy	17. Beech	31. Birch
4. Maple, white	18. Cherry	32. Pear
5. Maple, Norway	19. Mulberry	33. Cedar
6. Maple, red	20. Willow	34. Hawthorne
7. Maple, sugar	21. Ginkgo	35. Judas tree
8. Elm	22. Hackberry	36. Tulip poplar
9. Oak, pin	23. Pine	37. Sweet gum
10. Oak, black	24. Spruce	38. Buckeye
11. Oak, white	25. Hemlock	39. Larch
12. Magnolia	26. Linden	40. Kentucky coffee

C. Development

(1) Did the trees in your block come up of themselves? (2) Who plants the trees along the sidewalks in your town? (3) Who trims and cares for them? (4) Are trees along the sidewalks and roadways desirable? (5) What different habits of branching do you find among the trees of your home block? (6) Which kind are the tallest trees? (7) Which kinds have the greatest spread of branches? (8) Which of the trees are natives? (9) Which have been imported? (10) What types of trees should be considered for planting along sidewalks? (Consult a nursery catalog.) List those trees which grow quickly; those whose roots lie close to the surface and cause sidewalks to be upraised; those which are least resistant to disease and insect pests. (11) Why are the quick growing trees not so suitable? (12) Which need the least amount of care? (13) What is the proper method of trimming a tree? (14) What are the differences you note between streets lined with well cared for trees and streets having no trees? (15) What are the greatest enemies of our city trees? (16) What steps are taken by the city authorities to protect our trees?

Development for Report on Penn's "Greene Country Towne"

(1) What was Penn's original plan for preserving the natural beauty of Philadelphia? (2) How did Chestnut, Walnut, Spruce, Pine, and other streets in old Philadelphia get their names? (3) Are any of the original trees still growing? (4) How many public squares, as a result of William Penn's original plan, do we now have? (5) Did the founders of the village or city nearest you have a "plan" of development? How should the trees in public parks and squares be planted? (6) What types should be included? (7) Should the trees in a public square be trimmed? Why? (8) Do you know the kinds of trees in your nearest public square? (9) What is the work of a "tree expert"? (10) Is this a worthwhile vocation? Why? (11) What use is made of experts in caring for the trees in their public parks and squares? (12) What is Arbor Day? (13) When is Arbor Day? (14) Can a tree heal its wounds? (15) How may decaying trees be saved?

SUMMARY

In Pennsylvania can be found almost every type of tree known in the continent of *North America*.

Trees are desirable in our streets and public parks because of their *shade* and *beauty*. The beauty of a tree is due to its *shape* and depends largely on the way its *branches* are arranged.

Constant care must be exercised to protect our city trees from their greatest enemies, the *caterpillars* and the *Japanese beetles*.

Arbor Days are set apart twice a year by proclamation of the *Governor* for the *planting* and *preserving* of trees.

REPORTS

What is your city, village or township doing to Realize Penn's "Greene Country Towne" ideal?

Location of Trees in Your Neighborhood Which Were Growing When Penn Came.

PART III—FORESTS IN RELATION TO CONSERVATION

EXPERIMENT 5 (group experiment)

A. Problem

What kinds of soil hold the most water?

B. Experiment

Review "Experiment" and "Summary" of 7th Grade Course. "The Earth's Crust," Experiment 6-a.

C. Development (after "Conclusions" of Experiment 5)

EXPERIMENTS 5-A

A. Problem

What becomes of the leaves of our forest trees? How do roots prevent soil from washing away when it rains?

B. Experiment

1. Apparatus

Samples of leaf mold showing the upper and lower layers; reading glass.

2. Directions and observations

a. Carefully examine sample of leaf mold. Begin with the upper layer and work down toward the top soil. Note the changes that decomposition produces in the lower layers.

b. Note the thickness of the leaf mold carpet.

- c. Moisten well a portion of the top layer and a portion of the under layer of the leaf mold. Set aside and note which part dries out quickly and which dries out more slowly.

3. Conclusions

In answering the problem question explain what produces the changes you have noted. What is the great value of this carpet of the forest floor?

C. Development (after "Conclusions" of Experiment 5-b)

EXPERIMENT 5-B (class experiment)

A. Problem

How do roots prevent soil from washing away when it rains?

B. Experiment

1. Apparatus

Chalk box full of soil in which 6 or 8 corn or bean seeds have been growing for a week.

2. Directions and observations

- Grasp 2 or 3 of the growing plants by the stems and try to pull them out of the box. Note what happens.
- Empty the box by inverting it and tapping it against the table. Note whether much soil adheres to the plant roots.
- Carefully but thoroughly wash the roots of the plants. Note the root arrangement.

3. Conclusions

In answering the problem question explain how roots are able to hold the soil in place.

C. Development—Experiments 5, 5-a, and 5-b

- Why are so many springs found in forests? (2) Why are state governments so anxious to establish state forest reservations about the sources of their rivers? (3) How does preserving the forests aid in preventing floods? Recall 7th Grade Course, "Making Use of Water," Experiment 9. (4) What is "white coal"? (5) What are its advantages? (6) What relation have forests to the production of "white coal"? (7) In what way is your community dependent on "white coal"?

Development for Reports on "The Abuse of Forests by Lumbering Companies," and "Fire—the Red Menace of Our Forests."

- How old must a tree be before it can be used for lumber? (2) Why is the American method of lumbering wasteful? (3) With reference to methods of cutting and tree replacement what restrictions should the government enforce on lumbermen? (4) This method is practiced by what foreign governments? (5) With what results? (6) Why is fire the greatest danger to our forests today? (7) What is the average yearly loss due to forest fires in Pennsylvania today? (8) What are the chief causes of these destructive fires? (9) How does our state government attack the forest fire problem?

SUMMARY

Nature's Water Reservoir

Trees regulate the *water* supply and *enrich* the soil. The leaf mold of the forest floor produced by the *decay* of fallen leaves retains the *water* like a *sponge*, letting it out *gradually*. Their *root* growth prevents the washing away of soil.

Where land has been deforested destructive *floods* and erosion follow with the loss of *organic* soil.

Our Dwindling Wood Supply

Trees must be at least *fifty* years old before they are suitable for lumber. Our wood supply must be *conserved* by regulated *cutting* and *reforestation*.

Loss by *fire* is the greatest menace of our forests. Most forest fires are the result of *carelessness*.

REPORTS

The Abuse of Forests by Lumbering Companies

Fire—the Red Menace of Our Forests

Reference—"The State Forests of Pennsylvania," Bulletin 37, Department of Forests and Waters, Commonwealth of Pennsylvania, pages 44 to 53

PART IV—RECREATION IN THE STATE FORESTS OF PENNSYLVANIA

EXPERIMENT 6 (class experiment)

A. Problem

Why do the forests always feel cool and moist?

B. Experiment

1. Apparatus

Fresh leaf (geranium or other house plant); dry tumbler; tumbler nearly filled with water; card 3 x 5 inches.

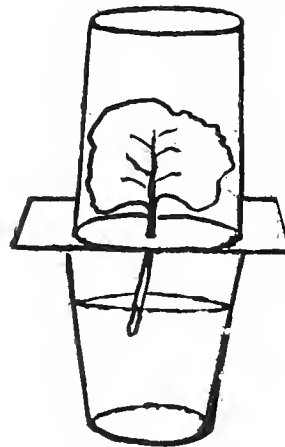


Figure 21

2. Directions and observations

Punch a small hole in the center of the card. Push the leaf stem (petiole) through the hole and into the water.

- Set up the apparatus as shown in the drawing. Place it in strong sunlight for about 20 minutes. Note what appears on the inside surface of the dry inverted tumbler.

3. Conclusions

From where must the material in the tumbler have come? This function of the leaves is called *transpiration*. Why do the forests feel so much cooler than the open fields? Why is the difference not due entirely to shade?

C. Development (after "Conclusions" of Experiment 6-a)

EXPERIMENT 6-A

A. Problem

How much water does a plant give to the air?

1. Apparatus

Potted plant (geranium or other house plant); water; platform balance; weights; sufficient waxed paper to cover the flower pot entirely; thread or string.

2. Directions and Observations

Water the plant well. When the excess water has drained off put the waxed paper around the pot and tie it around the plant stem in such a way that it prevents the evaporation of water from the soil.

- Place the plant on the balance and weigh. Record the weight. Carry the balance with the

plant in place to a sunny window. Reweigh at the end of 2 hours; 24 hours, 48 hours and calculate the loss of water due to transpiration.

- b. Record all the data in a table like the following:

<i>Time Intervals</i>	<i>Weights</i>	<i>Loss of Water</i>
Start of the experiment		
2 hours		
24 hours		
48 hours		

- c. Count the number of leaves on the plant and calculate the average amount of water given to the air by each leaf during a 24 hour period.

3. Conclusions

On the average, how much water was given off per day by the plant used in the experiment? In general, what effect has the size and number of leaves of a plant upon its rate of transpiration?

C. Development—Experiments 6 and 6-a

- (1) Would the forest be just as cool in summer if the trees had no leaves? Why? (2) Why is it hard for trees to grow along a cement- or asphalt-covered street? (3) Do forest areas have any effect on the production of rain? (4) What makes you think so? (5) Why does a tree grow taller in a forest than in the open? (6) When in a forest, how could you identify trees if you were unable to see the leaves? (7) Do you know what forest trees blossom in the spring before their leaves come out? (8) Do you know what forest tree blossoms in the fall? (9) Are squirrels friends of forest trees? Why? (10) Can you find, by observation, what trees are protected from insects by birds?

Developments for Reports on "Where Can I Build or Use a Summer Camp on State Lands?" and "How to Travel Through the Forests."

Examine the map shown in Bulletin 37 on "The State Forests of Pennsylvania" and a "Public Use Map" of Pennsylvania. (1) Where are most of the state forests located? (2) Which one is nearest your town? (3) In choosing a camp site in a state forest what natural conditions would you keep in mind? (4) In what pleasurable activities would you engage in a forest camp? (5) What rules does the state require visitors to observe in the forest? (6) How would you go about securing a camp site in a Pennsylvania State Forest? (7) How can you secure a camp site lease?

Development for Reports on "How to Stay Overnight in a Forest" and "How to Cook in the Forest."

- (1) What is the best method of building a "lean-to" in the forest? (2) What sort of floor covering would you use? (3) How can you keep the rain

out? (4) In building a fire what is the first thing you would do? (5) What is the best type of wood to use for burning? (6) How can you best secure a good draft for your fire? (7) What is the precaution every camper must take if he builds a fire? (8) What is the scout rule concerning the fire place when breaking camp? (9) What is the scout rule concerning the disposal of all refuse and waste when breaking camp? (10) Why should all empty bottles be carefully buried before leaving a camp site in a forest? (11) What is the scout rule concerning the picking of flowers and the respect and care of trees and tree branches while hiking or camping in a forest?

SUMMARY

Having a Good Time in the Forest

Camping and hiking in state forests is of value because it promotes personal *health*, teaches us to know living forms in their *natural* surroundings and to appreciate the importance of *conservation*.

Forestry as a Vocation

Forestry is a worth while profession because it is a health-giving, *outdoor* occupation and because of its great value to the *community* in *conserving* our greatest natural resource.

REPORTS

Where Can I Build or Use a Summer Camp on State Lands?

How to Travel Through the Forests

How to Stay Over night in a Forest

How to Cook in the Forest

The Opportunities in Forestry

How to Become a Forester

Where Can I Find a Bit of Forest Primeval in Pennsylvania?

NOTES ON METHOD

Experiment 1: (1) Oak wood is the best for showing the medullary or pith rays (2) Be careful not to confuse the ring enclosing the pith with the first annual ring. (3) If the cut ends of the branches and sections used in this and subsequent experiments of Part I are carefully sand-papered and shellacked, the detail will be more clearly brought out, and the specimens will last indefinitely.

Experiment 2a: If no strip of veneering wood is available, the thin sheet of cedar wood packed between layers of cigars in the cigar box will serve.

Experiment 4: This problem can be extended into a valuable project by compiling the class maps into a single map representing the territorial boundaries of the school.

Experiment 5a: It is best for the teacher to secure the section of leaf mold. If the lid and bottom of a cigar box are replaced by 2 glass plates, the specimen of leaf mold showing the various layers can be preserved in it and easily studied.

UNIT II

SOUND

GENERAL OBJECTIVES

A. Sound Is Not a Substance But the Result of Vibration

The concept is to be developed that sound waves obey definite laws.

B. The Relation of Sound to Music

The objective is to show that the laws of sound discovered by the scientist may be recreated into the art of music by the genius of the musical composer.

SPECIFIC OBJECTIVES

PROBLEMS FOR EXPERIMENT

DESIRABLE OUTCOMES

Sounding Bodies

Sounds and How They Reach Us

1. When will an object produce a sound? (group experiment)
2. How do sound waves travel to us? (group experiment)
- 2a. How does the ear receive sound waves?
- 2b. How do sound detectors locate fog signals?
- 2c. How can we measure distances by listening to sounds
3. Why does a cheer leader use a megaphone? (class experiment)

Knowledge:

1. Sound waves are produced by vibrating bodies.
2. Solids, liquids, and gases act as mediums for transmitting sound waves.
3. Sound waves may be reflected, producing echoes.

Sounds and Music

High Tones and Low Tones

4. How can we make objects give out high tones and low tones? (group experiment)
- 4a. How is the human voice produced?

4. To raise or lower the pitch of a tone we must quicken or slow up the speed of vibration of the sounding body.

Musical Instruments

5. How do musical instruments make sounds? (class experiment)
- 5a. How does the phonograph record sound? (class experiment)

5. Musical instruments may produce sound by vibrating strings, vibrating air, or vibrating membranes or masses.
6. Appreciation of the skill of the maker of good musical instruments; of the musician who knows how to get the best tones from them, and of the leader of an orchestra who knows how to combine them so as to produce the best harmony.

NOTES ON EXPERIMENTS

Experiment 1 can be performed by using the following apparatus and following these directions: 1—Apparatus: Tuning fork; *cigar box with one end removed and lid nailed down; 6-inch test tube; battery jar filled with water; rubber band. 2—Directions and observations: (a) Hold the base of the tuning fork on the cigar box. Note whether there is any sound. (b) Strike a prong of the tuning fork and hold the base against the cigar box. Note whether there is any sound. (c) Place the tips of the prongs of the tuning fork into the surface of the water in the battery jar before and after striking the prongs. Note carefully the difference in the effects on the surface of the water. (d) Press the thumb and finger lightly upon the prongs before and after striking them. Describe the difference in the sensation. (e) Place the test tube bat against the chin with the open end just below the lower lip. Hold the test tube lightly and blow across the open end. Describe the sensation in the fingers. Note whether any sound was produced. (f) Hold one end of the rubber band with your teeth and stretch the other end with your finger. Pluck the stretched string. Observe how the string behaves when stretched tightly enough to produce a sound. **Experiment 2** can be performed by observing the intensity of sound waves produced by a tuning fork one meter away and then observe what happens when the tuning fork is placed against meter

stick and the ear of the observer in contact with the meter stick at the other end. **Experiment 2-a** requires the use of a "telephone" constructed with baking powder can with a small hole punched in the center of the bottom through which a rosin covered cord with a knotted end is pushed. Compare the structure of the ear to this telephone. **Experiment 2-b** is performed by having pupil put one ear under water while another pupil at some distance lightly taps two stones together under the surface. **Experiment 2-c** requires the use of a watch in timing sounds made by objects at known distances. **Experiment 3** can be performed by showing how a megaphone concentrates sound waves figure 22. **Experiment 4** may be performed by using the following apparatus and following these directions: 1—Apparatus: Board about twenty inches long by four inches wide by one

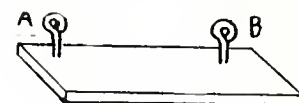


Figure 23

inch thick; two strong screw eyes; old violin or mandolin string; three six-inch test tubes; water, test tube support. 2—Directions and observations: Fasten the screw eyes in the board as shown in figure 23. Fasten one end of the string securely to screw eye "A". Wrap

*The cigar box is a homemade resonance box. Find out what resonance means.

two or three turns of the string about the shaft of screw eye "B" and secure the free end to the screw eye itself. (a) Twist screw eye "B" sufficiently to stretch the string. Pluck the string with the finger. Note whether the tone seems low or high and whether the vibrations seem to be noticeably slow or fast. (b) Twist screw eye "B" to stretch the string tighter. Pluck the string and note any change in the tone and rate of vibration as compared with the previous operation. (c) Place the finger on the string near screw eye "B". While the string is plucked run the finger slowly down the string to shorten the vibrating portion. Note any change in the tone (pitch) of the string. (d) While plucking the string slide the finger back toward screw eye "B" to lengthen the vibrating portion. Note any change in the tone (pitch) of the string. Directions "a", "b", and "c" show how stringed instruments raise and lower their tones. Place the three test tubes in the test tube support. Pour water to the depth of one inch in one tube; to the depth of two inches in another, and put no water in the third one. (e) Blow across the open end of the test tube filled with air as directed in Experiment 1 "e". Note whether the tone seems relatively low or high. (f) Blow across the open ends of each of the other two test tubes. Note what happens to the tone and which test tube gives the highest tone. Directions "e" and "f" show how instruments using vibrating air in air chambers raise and lower their tones. In these operations the water was used in the test tubes merely as a convenient method of shortening the air chamber. **Experiment 4-a** is performed by stretching two pieces of sheet rubber tightly across the bowl end of a thistle tube and blowing into the stem of the thistle tube. Compare this apparatus with structure of the larynx. **Experiment 5** may be performed by examining and observing some string instruments, wind instruments and percussion instruments and noting the way of changing the pitch of the tones of these instruments. In **experiment 5-a** examine a phonograph record with a reading glass, and examine the construction of the phonographic sound box.

DEVELOPMENTS

Experiment 1: (1) Can you produce a noise by waving your arms in the air? Why? (2) Why does the wind often "whistle" and overhead telegraph wires "hum" during a storm? (3) How do insects like the katydid, cicada, grasshopper, locust, and cricket produce their shrill sounds? (4) What is an aeolian harp? (5) How does it operate? (6) Why is it that heavy claps of thunder shake a house? (7) Make a list of ways in which sounds are used as warnings. (8) Why are troops required to break step when marching over a bridge?

Experiments 2, 2-a, 2-b, and 2-c: (1) Why would it be very difficult to hear sounds on the moon? (2) Why can you hear an approaching trolley car better if you put your ear to a trolley pole which supports the wire? (3) Why was it so difficult for soldiers to cut the barbed wire in "no man's land" without being heard by the enemy? (4) Why can deaf children "listen" to music by resting their hands or heads on the piano? (5) Explain why a bell rung in a vacuum makes no noise. (6) Explain why it is dangerous to have a very violent noise occur close to the ear. (7) Why do gunners stand on their toes, cover their ears and open the mouth when a heavy charge

is fired from artillery (8) Suppose there were a five-second interval between the lightning flash and the thunder, about how far away is the storm? (9) How could you tell whether a thunder storm was approaching or going away?

Experiment 3: (1) Why is it harder for a speaker to be heard in the open air than in a hall? (2) Why does a radio speaker need a horn? (3) Why is an ear trumpet of aid to partially deaf persons? (4) Why do some churches have a sounding board over the pulpit? (5) What is the most desirable shape for a room to be used as an auditorium? (6) When will a room produce more echoes, when it is empty or when it is filled with people? (7) How do you explain the action of a whispering gallery? (8) Why do subway cars make more noise than surface cars? (9) What examples of echoes out of doors can you give? (10) Are there any conditions indoors which may produce echoes? (11) How is it that you can hear a roar in a sea shell when you put this shell to your ear? (12) Are you really hearing the sound of the sea as many people think?

Experiments 4 and 4-a: (1) Upon what principle does the pitch of a tone depend? (2) Why does the pitch rise as water is being poured into a tall cylinder or bottle? (3) How do you account for the drop in the pitch of sounds produced by a revolving saw as it cuts through the harder part of a board? (4) Why is the whistle of a peanut roaster so shrill? (5) Why is the sound made by a humble bee lower in pitch than the sound made by a mosquito? (6) How does the voice as heard over the radio or in the talking moving picture differ from the actual voice of the speaker?

Experiments 5 and 5-a: (1) What is the difference between a noise and a tone? (2) Why are the lower pitched strings of a harp or piano made so thick? (3) Why must the body of a violin be hollow? (4) How is resonance produced in the horns? (5) Why does the flute have a softer tone than the horn? (6) How are phonograph records made? (7) What is a "dictaphone"? (8) What is the principle of recording sound upon such an instrument? (9) What is the principle of reproducing sound upon this instrument? (10) How is the "sound" recorded and reproduced in the talking moving pictures?

SUMMARY

In order for an object to give out sound waves it must *vibrate*. When an object moves quickly *back and forth* it is said to *vibrate*.

A sound medium is a substance which is able to *transmit* sound waves from a *vibrating* object to the *ear*. The best media are *solids* and *liquids*; the poorest are *gases*. Reflection of sound is changing the *original* direction in which the sound waves were *moving*. Echoes are caused by *reflected* sound waves.

The pitch of a tone depends upon the rapidity of *vibrations* an *object* makes. The quicker the *vibrations* the *higher* is the pitch. The slower the *vibrations* the *lower* is the pitch.

Musical Instruments

Musical instruments may be *stringed* instruments, *wind* instruments, or *vibrating* membranes or masses.

In making a *phonograph* record we make sound *waves* produce *wavy* lines on the record. In playing the record these *wavy* lines are made to produce sound *waves*.

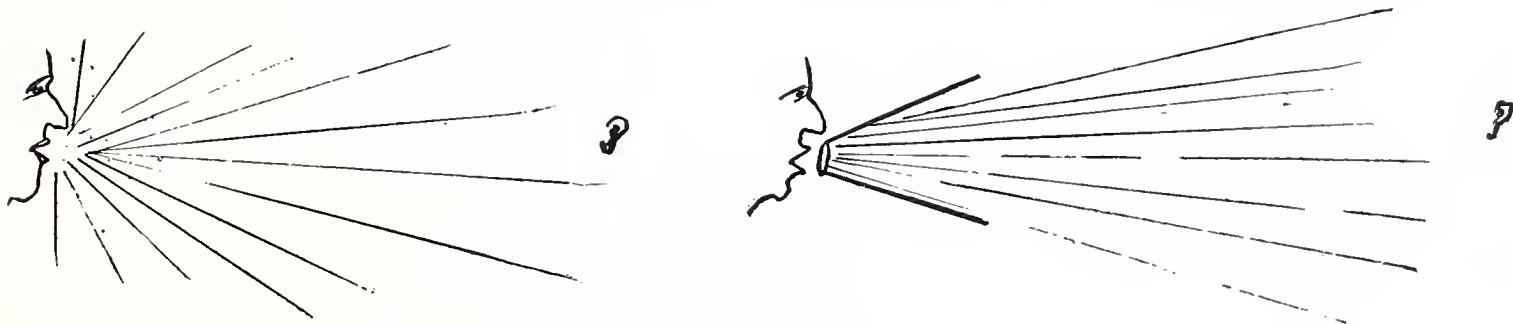


Figure 22

UNIT III

MODERN COMMUNICATION

GENERAL OBJECTIVES

To appreciate the convenience and importance of the telegraph, telephone, and radio in bringing the peoples of the world in closer and more harmonious contact.

It is not the purpose to develop the electronic theory of matter to explain radio.

SPECIFIC OBJECTIVES	PROBLEMS FOR EXPERIMENT	DESIRABLE OUTCOMES
The Telegraph and Electric Bell	1. How does an electric telegraph instrument work? (group experiment). 2. How does an electric bell work? 2a. How may I install electric bell circuits in my home?	Knowledge: 1. That the telegraph and telephone are applications of electro-magnetism.
The Telephone	3. How does a telephone reproduce sound? 3a. How can I make a telephone transmitter?	
Wireless and Radio	4. Can electromagnetic waves go through space? 5. How may we send and receive radio waves? (class experiment). 5a. What are the parts of a radio vacuum tube?	2. That radio communication depends upon electrical vibrations.

NOTES ON EXPERIMENTS

Experiment 1 can be performed by making a telegraph following the diagram in figure 24. **Experiment 2** can be performed by showing how a bell works, using a bell similar to that indicated in figure 25. In **experiment 2-a** pupils may install electric bell circuits in their own homes. **Experiment 3** and **experiment 3-a** can be demonstrated by using the telephone, and carefully studying the parts of the receiver and the transmitter. **Experiment 4** can be performed by using a telephone transmitter and a telephone receiver (see figure 26). **Experiment 5** can be performed by using the following apparatus and following these directions: 1—Apparatus: Electric bell gong removed; push button; two dry cells; four one hole stoppers; forty feet annunciator wire; twine; crystal detector; tuning coil; telephone receiver or radio head set; wooded base for mounting detector and tuning coil. 2—Directions and Observations: Burn off the insulation from two fifteen feet lengths of annunciator wire to serve as antenna or aerial wires. Stretch one aerial across each end of the

room. Insulate the wires from the wall with rubber stoppers. Arrange and connect the apparatus as shown in figure 27. For the "ground" connection use the radiator pipes. First, scrape clean the part of the pipe where you wrap the bare ends of the ground wires. (a) Trace the circuits of the broadcasting set and the receiving set. The bell and push button circuit represents the broadcasting station. The crystal detector, tuning coil and telephone receiver represents the receiving set. (b) Listen at the telephone of the receiving set while another pupil presses the button several times at the broadcasting station. What effect is noticed in the telephone? Note: 1—In making contact between the coiled wire (cat's whisker) of the detector and the crystal, the wire must rest upon a sensitive spot. To locate this spot try the wire on various places of the crystal, listening in the telephone receiver for the spot which gives the loudest signals. 2—In operating the receiving set, move the slides slowly back and forth across the tuning coil until the broadcasting signals come in clear and loud. In **experiment 5-a** study the part of an old wornout three electrode radio tube.

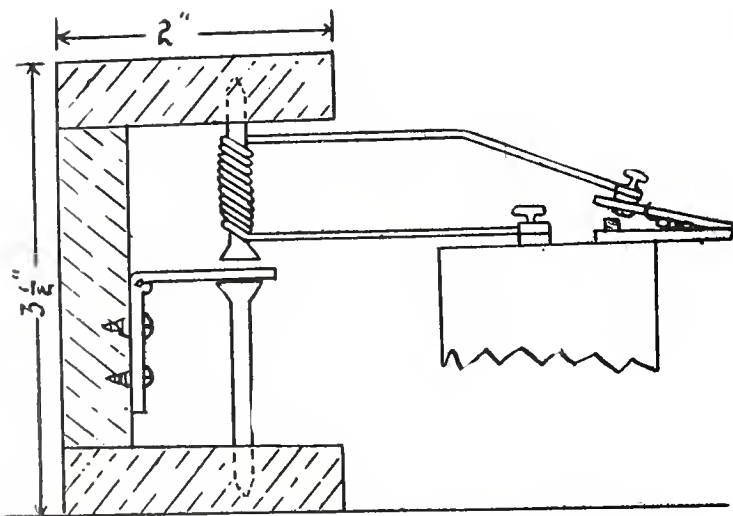


Figure 24

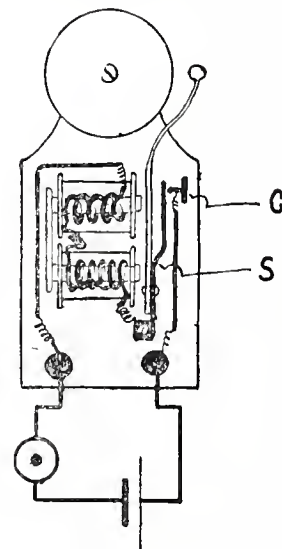


Figure 25

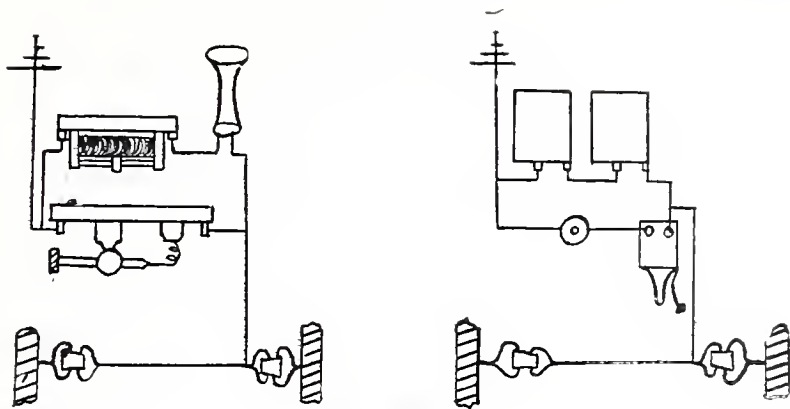


Figure 26

DEVELOPMENTS

Experiment 1: (1) Who was Morse? (2) When did he succeed with this invention? (3) What was the first message sent? (4) What is a dot in the telegraph code? (5) What is a dash? (6) Copy the Morse code. (7) What is the signal apparatus that the firemen call the "joker"? (8) How are fire alarm signals received in your local fire house?

Experiments 2 and 2-a: (1) What is an automatic circuit breaker? (2) What does it cause in the sound of the bell? (3) What are the possible things that can be wrong with your front doorbell at home? (4) Some bells are made which do not have an automatic circuit breaker. How will their sound differ from the ordinary electric bell?

Experiments 3 and 3-a: (1) Who was Alexander Graham Bell? (2) What are the three essentials of a telephone? (3) What are the most recent improvements in this instrument? (4) What is the literal meaning of the word "telephone"? (5) What are the advantages of the telephone as compared with the telegraph? (6) Visit a telephone exchange and be able to explain as a result of your trip: How a call is received at the exchange; how it is completed; how long distance telephoning is accomplished. (7) What is meant by the "automatic telephone"?

Experiment 4: (1) The word radio is derived from the word radiate. Literally what does it mean? (2) What is meant by radio waves? (3) In what direction do they travel? (4) How fast do they travel? (5) Are radio waves sound waves? Explain. (6) What connection has Marconi with wireless transmission? (7) Why is it necessary to have aerial wires of both receiving and broadcasting sets of exactly the same length?

Experiments 5 and 5-a: (1) What are the advantages of a vacuum tube set over a crystal set? (2) With reference to radio what is meant by oscillations, tuning, amplification, radio frequency, audio frequency, detector, condenser? (3) When does a vacuum tube become an oscillator? a detector? an amplifier? (4) How has the "B" battery

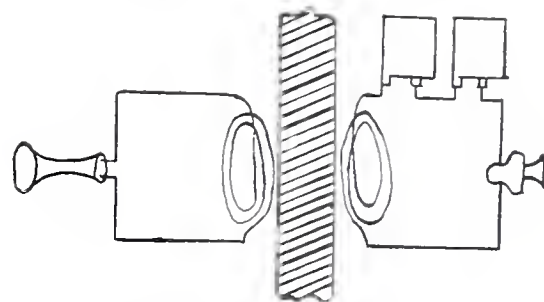


Figure 27

been eliminated in the modern radio set? (5) How has the "A" battery been eliminated? (6) What is the great advantage of an electro-dynamic speaker over the electro-magnetic speaker? (7) What is meant by control by radio? (8) How is it being used? (9) What contribution has each of the following made to radio science: Dunwoody, Edison, Fleming, De Forest?

SUMMARY

Pressing down the key closes the circuit making a *click*, as the sounder or armature strikes. When the key is released the armature again *clicks* as it falls away from the magnet. If there is a very short time between *clicks* the operator receiving the message knows it to be a *dot*; if a longer time, he knows it must be a *dash*. This dot-dash alphabet is known as the *Morse* code.

Fire signals are sent upon a *telegraph* instrument having a *bell*, which is struck by the armature. Instead of the clocking sound there is a tap upon the *bell*. Each fire alarm box has its own *number* which is tapped out by the *bell* in each fire house.

An electric door-bell is a practical application of an *electromagnet*. The continuous ringing of the bell is due to the series of rapid breaks in the circuit produced by the *automatic circuit breaker*.

The essentials of a telephone are a *transmitter*, a *circuit*, and a *receiver*. The *transmitter* causes *sound* vibrations to set up variable electric currents in the *circuit*. The *receiver* causes the variable electric currents to operate its *disc* and set up *sound* vibrations.

Wireless or radio vibrations belong in a class with *electromagnetic* vibration. Radio broadcasting sets change *sound* vibrations to rapidly *alternating electrical* vibrations which can travel quickly through space. Radio receiving sets collect or intercept these vibrations, reduce them to slower, *direct electrical* vibrations and then change them into *sound* vibrations.

UNIT IV

MODERN TRANSPORTATION

GENERAL OBJECTIVES

The objective is to realize our dependence for transportation upon the electric motor and dynamo, and the steam and gas engines.

SPECIFIC OBJECTIVES	PROBLEMS FOR EXPERIMENT	DESIRABLE OUTCOMES
Motors and Dynamos	1. What makes a street car go?	Knowledge: 1. That a dynamo translates motion into electricity and a motor translates electricity into motion. Upon this depends the operation of the trolley car.
Steam Engines	2. What makes a steam engine go? 2a. How does a steam engine piston work? (class experiment) 2b. What makes a steam turbine work? (class experiment)	2. That a locomotive engine depends upon the expansion of steam for its motion.
Gas Engines	3. How do explosions run engines? (teacher experiment)	3. That automobile and air plane engines depend upon the explosion of gases for their motion.
Air Planes	4. Why do air planes glide in the air? (group experiment) 4a. What keeps an air plane moving through the air?	4. That air planes depend upon air resistance and forward speed developed by their engines and propellers to sustain them.

NOTES ON EXPERIMENTS

Experiment 1 can be performed by operating a St. Louis type motor with dry cells and by turning the handle of the magnets. **Experiment 2** can be performed by showing the force of steam in a corked test tube containing water held over a flame. In **Experiments 2-a and 2-b** figures 28, 29 and 30 will help to explain how a steam engine piston and a steam turbine works. **Experiment 3** can be performed by following the plan indicated in figure 31. **Experiment 4** can be performed by using the following apparatus and following these directions: 1—Apparatus: Feather, coin, thin sheet of paper, handkerchief, string, two match sticks. 2—Directions and observations: (a) Stand on a chair or on a table, holding the feather in one hand and the coin in the other. Let both objects fall at the same instant. Which reaches the floor first? (b) Repeat the operation but use the thin sheet of paper and the coin as the object. Describe how the paper falls. Construct a parachute by tying a piece of string to each corner of the handkerchief and fastening the free ends of the string to the match stick. (c) Stand on the table and allow the parachute and the other match stick to fall. Note which sinks quickly and which slowly. In **Experiment 4-a** (a) First allow a paper plane to drop

from a height; (b) then throw the plane across the room, giving the plane a thrust forward, pointing it slightly upward. Contrast behavior with (a).

DEVELOPMENT

Experiment 1: (1) Where is the dynamo located in the electric car system? (2) Where is the motor? (3) How does the current get from one to the other? (4) How are dynamos operated? (5) What is the cheapest way to operate a dynamo? (6) Name some places where dynamos are operated. (7) Make a diagram of a trolley car in operation showing the location of the motor and dynamo, and naming the parts in the drawing.

Experiments 2, 2-a, and 2-b: (1) How is the knowledge gained in these experiments applied to the operation of steam engines and steam turbines? (2) In a science text look up the explanation of how a steam engine works and be able to answer the following: (a) What is a steam chest? (b) How does the valve from the steam chest operate to control the automatic movement of the piston? (c) What is the eccentric? (d) What is its value?

Experiment 3: (1) Why is the gas engine called an internal combustion engine? (2) How is the explosion produced? (3) How do gas engines differ essentially from

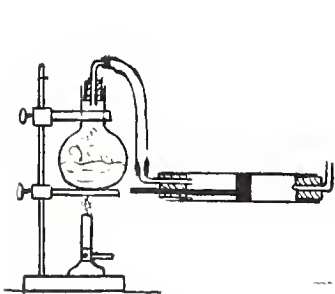


Figure 28

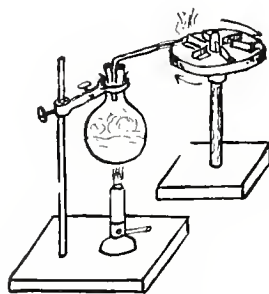


Figure 29

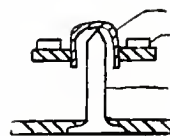


Figure 30

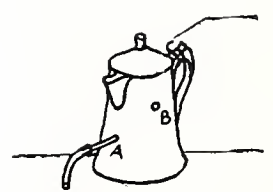


Figure 31

steam engines? (4) Why is a gas engine used in automobiles and air planes rather than steam engines? (5) In a science text read how an automobile engine works and explain what is meant by the suction stroke, the compression stroke, the power stroke and the exhaust stroke. (6) Why is it of advantage to keep the cylinders of gas engines cool while just the opposite is true of steam engines?

Experiments 4 and 4-a: (1) What is the difference between a glider and an air plane? (2) In the commercial air plane what furnishes the force which your arm supplied in Experiment 4-a? (3) Which part of an air plane sustains it in the air? (4) What part advances the air plane? (5) What causes it to rise in the air? For what achievement in air travel are the following noted: (6) Orville and Wilbur Wright? (7) Bleriot? (8) Commander Read of the United States Navy? (9) Alcock and

Brown? (10) Lindbergh? (11) Commander Byrd? (12) Earhart and Stultz? (13) Post?

SUMMARY

An electric motor converts *electricity* into *motion*, hence the name motor. A dynamo or generator converts *motion* into *electricity*.

In the locomotive and other steam engines the steam under great *pressure* is allowed to expand *alternately* on each side of a piston.

In the automobile and air plane engines a mixture of gas and air is *exploded* to produce the *pressure* on the pistons.

Air planes are sustained in the air because air offers *resistance* to bodies moving through it. The *horizontal* flight of an air plane depends largely upon its forward motion produced by means of its *engines* and *propellor*.

UNIT V

THINGS AND HOW THEY ARE MOVED

GENERAL OBJECTIVES

Solving the Problem of Work

The objectives are:

1. To define work in its relation to the movement of masses.
2. To understand the practical application of inertia and weight in producing motions of objects.
3. To investigate weight, friction, and inertia as hindrances to work.
4. To demonstrate the principles by which such simple machines as the lever, pulley, and the inclined plane lighten man's work.

SPECIFIC OBJECTIVES	PROBLEMS FOR EXPERIMENT	DESIRABLE OUTCOMES
Why objects Move Matter in Space	1. Is a tumbler ever empty? (group experiment)	Knowledge: 1. That all matter takes up space and has 3 dimensions.
Inertia	2. Why do we "lurch" while strap hanging in a street car?	2. Of the effects of inertia and weight in producing motion.
Weight	3. Why do we say "what goes up must come down"? (class experiment)	
Time in Motion	3a. How does a pendulum keep time? (teacher experiment)	3. Appreciation of the fact that time depends on motion.
How Man Lightens Work		
Scientific Work and Its Hindrances	4. What does the scientist mean by the word "work"? 4a. What makes "work" difficult? (group experiment)	4. Ability to discriminate between the popular and scientific notion of work.
Simple Machines	5. How can we lift things more easily? 6. What is the easiest way to get a barrel on a truck? (class experiment) 7. Why do riggers use pulleys? (group experiment)	5. Knowledge that inertia, weight, and friction as resistances to work may be overcome by the use of simple machines.

NOTES ON EXPERIMENTS

Experiment 1, figure 32, suggests how to demonstrate that a tumbler is never empty, answering the question of this experiment. **Experiment 2** can be performed as

illustrated by figure 33. **Experiment 3** can be performed by using the following apparatus and following these directions: 1—Apparatus. Blackboard eraser, pencil eraser, hollow rubber ball, spring from an old window shade roller, 2 similar textbooks, piece of string.

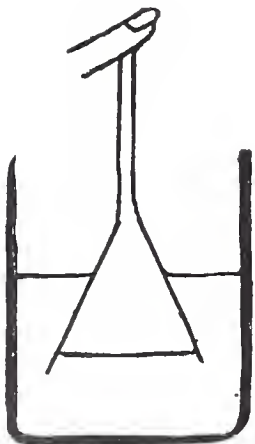


Figure 32

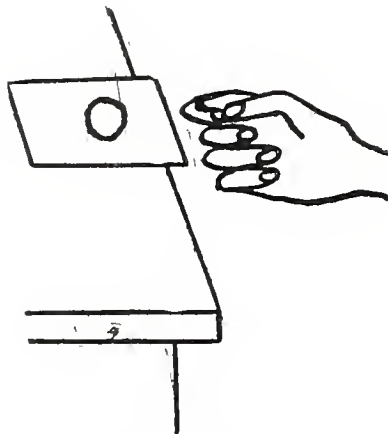


Figure 33

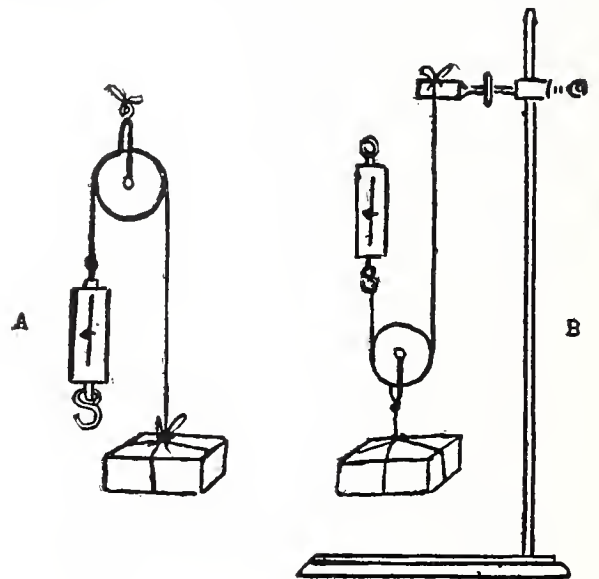


Figure 34

2—Directions and observations: (a) Hold the blackboard eraser at arm's length and then release it. Do the same with the pencil eraser and the ball. Which way do the objects move—toward the earth or toward the sky? (b) Toss the rubber ball a few feet into the air. What direction does it travel after it has reached the highest point in its flight? (c) Attach the upper end of the spring to a support. To the lower free end fasten both books by means of the string. Place one hand under the books and raise them until the spring is no longer stretched. Carefully remove the hand. Which way do the books move? What happens to the spring? (d) When the books come to rest measure the length of the stretched spring and record it. Remove one of the books and proceed as before again measuring and recording the length of the spring. Compare the 2 records for differences in length of spring. **Experiment 3-a** can be performed by using a weight suspended on a string of a given length, count the number of swings per minute. Vary the length of the string. Compare differences in number of swings per minute. **Experiment 4** can be performed by using the following apparatus and following these directions: 1—Apparatus. Two tumblers or beakers of equal size, mercury, water. 2—Directions and observations: In one tumbler pour some water and in the other pour an equal volume of mercury. (a) Lift the tumbler of water through a distance of 12 or 15 inches and place it on the table again. Now lift the tumbler of mercury through the same distance and return it carefully to the table. Note any differences in effort necessary to lift each tumbler. Use the same hand in lifting each tumbler. **Experiment 4-a** can be performed by placing in a row a flat pebble, blackboard eraser, a marble, a heavy pencil eraser. Push the object down the table by one shove of a yard stick. Reason out why each object comes to rest at a different place. **Experiment 5** can be shown by simple lever experiments. **Experiment 6** can be performed by showing how the inclined plane can be used to load trucks. **Experiment 7** can be performed by using the apparatus shown in figure 34.

DEVELOPMENT

Experiment 1: (1) What is a diving bell? (2) Why cannot liquid be poured quickly into a bottle without a funnel? (3) What does the scientist mean by "extension"? (4) What are the three dimensions of anything? (5) Can you think of a thing with only two dimensions?

Experiment 2: (1) Why are so many people thrown through the wind shields of their automobiles when accidents happen? (2) Why can a juggler suddenly pull a table cover from beneath a set of dishes without pulling the dishes upon the floor? (3) What does "inertia" mean? (4) What happens when we shake the dirt out of a rug? (5) Do we really shake the dirt away from the rug? (6) Explain pounding the end of a hammer handle to drive on the head. (7) Why does a sudden blow on a tree knock the fruit down?

Experiments 3 and 3-a: (1) Does it make any difference so far as earth pull is concerned whether an object weighing five pounds is feathers or lead? Why? (2) What is a plumb line? (3) Who uses it? Why? (4) Why should a wall be built "plumb"? (5) How is gravity responsible for making iron sink in water and wood float on water? (6) Is a "swing" a pendulum? (7) What part does the pendulum take in regulating the speed of a clock? (8) How is this accomplished? (9) What is the anchor movement? (10) Who was Galileo? (11) What is the story of his connection with the pendulum? (12) What is a "metronome"?

Experiments 4 and 4-a: (1) Does "work" as used by the scientist mean more than the popular notion of just "doing something"? (2) List six different things that you have

done recently that would be classed by a scientist as work. (3) Decide which of the following could be called work from a scientific standpoint: thinking about a football game; reading an account of how to play football; throwing a "forward" pass while playing in a game of football. (4) Why does the motorman use sand on the street car track in rainy weather? (5) Why do we strew ashes on the pavement in a sleet storm? (6) What has been your experience while dragging a sled over different kinds of surfaces? (7) Why do we oil machinery? (8) What is the action of a "brake" on a truck? (9) What is a "hot box" in railroading language?

Experiment 5: (1) What are three different kinds of machines man uses to lighten his work? (2) What is a good definition of a simple machine or engine? (3) What type of machine is a see-saw? (4) Make a list of all the things used in your home which lighten work. (5) Make another list of all kinds of work that you see being done by workmen in the streets, indicating what devices are used to do this work.

Experiment 6: (1) What is the principle of the screw? (2) The wedge? (3) Which resistance to work does the inclined plane overcome? (4) What is the easiest way to climb a hill?

Experiment 7: The pulley is really a modified lever. (1) Determine by examination and record by sketches where the fulcrum, the power arm, and the load are. (2) What is the advantage of the fixed pulley? (3) Why has the movable pulley the greater mechanical advantage? (4) Which of the three resistances to work does the pulley overcome?

SUMMARY

All matter takes up space. Two things cannot be in the same place at the same time. That is why a tumbler is never empty.

Matter has only 3 dimensions, *length*, *breadth*, and *thickness*.

How Inertia Affects Bodies

Bodies in motion tend to *continue* so. Bodies at rest tend to *remain* at rest. Disturbance of bodies must come from *outside* as objects cannot move of themselves. Inertia is the property of matter by virtue of which it must *remain* either in *motion* or at rest and continue so until *acted* upon from *outside*.

Weights tend to move toward the *earth*.

How the Pendulum Keeps Time

The swings of the pendulum are always *constant*. The greater the length of the pendulum, the *slower* the swings. The shorter the length of the pendulum the *faster* the swings.

Work results when the application of force or effort makes an object *move* a definite *distance*.

The resistances to work are: *weight*, *friction*, and *inertia*. A simple machine or engine is a device that makes work *easier*. The lever is a type of *machine*.

Some simple machines or engines are: *lever*, and its modifications, the *pulley*; *wheel* and *axle*; *inclined plane* and its modifications, the *wedge* and *screw*.

The less the angle of the inclined plane the less the *power* required to overcome the *resistance*.

Modifications of inclined planes are the *screw* and *wedge*.

The pulley is a *lever* with a fulcrum *between* the power and the load. The pulley overcomes *weight* resistance.

There are 2 kinds of pulley riggings, *fixed* and *movable*. The *movable* pulley has the greater mechanical advantage.

UNIT VI

AIR AND WEATHER

GENERAL OBJECTIVES

A. Determining Weather Changes

The objectives are:

1. To show that weather results from changes in the pressure and temperature of the air.
2. To discriminate between real and fictitious weather signs.

B. Making Use of Compressed Air and Air Pressure

The objective is to show the use of compressed air in industry, such as automobile tires, sand blast, automatic door check, and of air pressure in the siphon and lift pumps.

SPECIFIC OBJECTIVES	PROBLEMS FOR EXPERIMENT	DESIRABLE OUTCOMES
Knowing the Weather Winds	1. What makes the wind blow? (group experiment)	Knowledge: 1. That wind is air put in motion through changes in air temperature.
Air Temperature and Air Pressure	2. How do thermometers indicate difference in temperature? 3. How does a barometer measure air pressure? (class experiment) 3a. Is there any relation between barometric pressure and temperature?	2. That thermometers measure differences in air temperature while barometers measure air pressure. 3. That low pressure areas have relatively high temperatures while high pressure areas have lower temperatures.
Air and Moisture	4. When does the family wash dry most rapidly? 4a. What makes a glass of ice water "sweat"?	Realization that warm air of low pressure absorbs moisture, while a fall in temperature condenses the moisture, forming dew, fog, clouds, rain, hail, or snow.
Weather Forecasting	5. How does the weather man predict stormy weather?	Ability to interpret a U. S. Weather Map.
Practical Uses of Compressed Air and Air Pressure	6. How can we make water run uphill? (group experiment) 6a. Is air elastic? (class experiment)	Knowledge: 1. That air pressure may be put to use in pumps, siphons, etc. 2. That air may be compressed and put to practical use.

NOTES ON EXPERIMENTS

Experiment 1 can be performed by noting the action of sticks of Chinese punk held at the end of an ordinary lamp chimney; also, by lighting an ordinary lamp and closing the perforated surface at the wick space. Again permit the lamp to burn naturally and hold a piece of cardboard against the top of the chimney. **Experiment 2** may be performed by placing a thermometer in cracked ice and noting its lowest temperature. After this is noted, heat the cracked ice until it is melted and continue until the water boils. Note this temperature. The highest and lowest temperatures you have recorded will approximately coincide with the "fixed points" of the thermometer. **Experiment 3** can be performed by following the procedure indicated in figure 35. **Experiment 3-a** can be performed by constructing graphs to show differences in barometric pressure and temperature from day to day using data clipped from the weather report in a daily paper. When the barometric pressure line goes up, what does the temperature line do? **Experiment 4** can be performed by recording each five minutes until dried, the stages of two wet handkerchiefs of equal size, one placed over a radiator and the other placed out of doors in the cold. **Experiment 4-a** can be performed by noting what soon collects on the outside of

a dry tumbler filled with ice. **Experiment 5** can be performed by noting changes indicated on a set of four or five United States government weather maps of con-

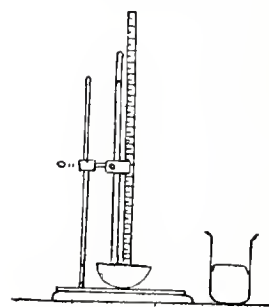


Figure 35

secutive dates and noting whether the rain and cloud areas precede or follow the "Low" as it crosses the country. **Experiment 6** can be performed by constructing a simple siphon. **Experiment 6-a** may be shown by measuring the volume of water and compressed air a basketball will contain.

DEVELOPMENT

Experiment 1: (1) How are land and sea breezes caused? (2) What causes monsoons? (3) Where is the hottest part of a room? (4) How does a hot air heating system work in a private home? (5) How should the windows be arranged in order to ventilate a room?

Experiment 2: The action of the substance in a thermometer is due to expansion. (1) What is expansion? (2) When will it take place? (3) Why do we not use water in thermometers?

Experiments 3 and 3-a: (1) What is an aneroid barometer? (2) Who was Torricelli? (3) How does an aviator discover how high he flies? (4) Of what use is a barometer to mountain climbers? (5) What department of the U. S. Government makes daily use of the barometer? (6) What do "High" and "Low" mean on a weather map? (7) What are the wind directions near a "Low"? (8) How is this explained? (9) Why are "Lows" called "storm breeders"?

Experiments 4 and 4-a: (1) What is the cause of rain? (2) Of fog? (3) What makes cellars and caves damp? (4) When do we see fog in the subway? (5) How does the hairdresser dry the hair? (6) What is humidity? (7) Have you used an electric towel? How does it "dry" the hands?

Experiment 5: (1) From what large body of water does most of our moisture come? (2) What would be the most necessary instruments for recording conditions that would aid in predicting weather? (3) What does the official weather man do with his records in addition to recording them in his own office? (4) What are some reliable weather signs? (5) What is the legend of St. Swithin? (6) Of Ground Hog Day? (7) Wet moon, dry moon? (8) Has science found any bases to substantiate these superstitions? (9) Of what use are weather forecasts?

Experiments 6 and 6-a: (1) How is the siphon principle used in our homes? (2) How is it used in getting water to large cities? (3) Was Torricelli right or wrong in his explanation of this problem? (4) How can water be taken from a washing machine by this apparatus? The siphon depends on the creation of a vacuum. (5) What is a vacuum? (6) How does a pump get water from a well? (7) What is compressed air? (8) What are "balloon" automobile tires? (9) What are "air brakes" and where are they used? (10) How is cash sent to the cashier in some department stores? (11) How is compressed air used by the Post Office? (12) How does the whistle operate on a subway train? (13) Study in this connection an air rifle, a pneumatic inkwell, a sand blast, a pneumatic drill, a door check. (14) What is a cartesian diver?

SUMMARY

Heated air rises and cool air falls to take its place. Wind is *air in motion*. Wind is caused by the *unequal* heating of the earth's surface.

In order to ventilate a room the window sash should be *lowered* a few inches from the *top* and *raised* a few inches from the *bottom*.

Heat causes matter to *expand*. When heated, the colored water *rises* in the thermometer tube. Mercury, alcohol, ether, chloroform, or carbon tetrachloride are used in thermometers, as water freezes at a higher temperature than they do.

The mercury in the barometer is kept up in the tube by the *pressure* of the air outside. When the *pressure* outside increases the mercury *rises* in the tube. When the *pressure* of the air decreases the mercury column *falls* in the tube.

"High" and "Low" on a weather map refer to the height of the mercury column in a *barometer*. Cool air from "*Highs*" blows toward "*Lows*" from which the heated air has *risen*. This rush of air makes a *wind* storm.

More moisture is held by *warm* air than by the same amount of *cool* air. Air that is *warm* and moisture-laden will give up its moisture when *cooled*.

Storms originate at "*Lows*". "*Low*" means *low* barometer pressure, hence *high* temperature with much moisture. Winds moving from "*Highs*" to "*Lows*" chill the moisture-laden, warm air and *storms* result.

Weather forecasts of the United States Weather Bureau are of use to *business men*, *mariners*, *railroad* and *shipping* interests, and *aviators*.

Some reliable signs of a change in weather are the change in the loudness of the sounds of *whistles*.

Atmospheric pressure *forces* water *upward* into the siphon to fill the *vacuum* produced there by the falling water. In the experiment the *weight* of the water in the longer leg causes it to fall downward into the lower jar. This creates a *vacuum* within the U-tube. The water from the upper jar is *forced* by atmospheric pressure through the *shorter* leg into the *longer* leg when the short leg end of the U-tube is under the water.

Because air is elastic it can be *compressed*. Automobile tires depend upon *compressed* air to make them springy and comfortable to riders.

UNIT VII

GARDENING

GENERAL OBJECTIVES

A. Making a Garden

The objectives are:

1. To appreciate that good gardens depend on careful planning.
2. That gardening is a profitable occupation and a healthful and enjoyable use of leisure time.

B. The Importance of Soil to Man

The objectives are:

1. To demonstrate why soil is the water reservoir of life.

SPECIFIC OBJECTIVES	PROBLEMS FOR EXPERIMENT	DESIRABLE OUTCOMES
How to Grow Plants Water, air, and warmth	1. What conditions do seeds need to grow? (group experiment) 1a. Do sprouting seeds need air? (class experiment) 2. How deep should seeds be planted? (class experiment)	Knowledge: 1. That seasonal weather conditions govern planting.
Planning a Garden	2a. How can I obtain a library of garden information? 2b. How can I plan my home garden?	2. That successful gardening requires forethought and specific information.
New Plants from Old	3. How can we obtain new plants without using seeds? (group experiment) 3a. How is budding and grafting done? (group experiment)	3. That plants may be propagated by several methods.
Soils and Soil Cultivation Soil, Water and Soil Fertility	4. What kinds of soils hold water best? (class experiment) 4a. How does the use of fertilizer affect growing plants? (class experiment) 5. Of what value is a fine surface layer of soil? (group experiment) 5a. Why do farmers "cultivate" or pulverize the top layer of soil? (class experiment)	Realization that: 1. Soil becomes the water reservoir of life because of its ability to conserve moisture. 2. Pulverizing top soil conserves soil water by retarding evaporation and also distributes fertilizing materials.

NOTES ON EXPERIMENTS

Experiment 1 can be performed by using the "Rag-doll" methods of germination and noting results at four, six and eight day intervals under varying conditions. **Experiment 1-a** consists in attempting to sprout moist seeds in an open tumbler and in a closed tumbler. **Experiment 2** is an actual test of the depth of planting. In experiments **2-a** and **2-b** write to the state and federal departments of agriculture for helpful booklets. **Experiment 3** can be performed by placing healthy begonia leaves, shoots of the common geranium or vigorous twigs of willow or poplar trees in water or moist earth. **Experiment 3-a** can be performed by securing the following material: a vigorously growing piece of fruit tree branch about the diameter of your smallest finger; some branches or twigs holding well developed lateral buds; a sharp knife; strip of soft rag; a jar of water. Proceed as follows: Cut the letter "T" on the branch down to the green layer. From the twig select a bud; cut it off below the green layer. Place the bud in the "T" so that the two green layers touch. Wrap the bud with the rag strip so that the two green layers are kept in contact. Place the "budded" branch in the jar

of water and observe every few days. Consult your textbook for directions in grafting. **Experiment 4** can be performed by using flower pots filled with sand, clay and humus, and measuring the amount of water each will retain. **Experiment 4-a** can be performed by using two pans each about one foot square; washed sand to fill the pans; twenty-four lima beans; commercial fertilizer selected from table below. Figure out from the table just how much fertilizer should be used for one square foot. Mix this with the sand in one pan. Plant half of the beans in this pan and the other half in the unfertilized pan of sand. Observe differences in growth at end of two weeks. **Experiment 5** can be performed either with soil or by using a square of cube sugar heaped with powdered sugar in a saucer. With a pipette place colored water at base of cube. Note what happens. **Experiment 5-a** can be performed by tying a piece of cheese cloth over the lower end of two lamp chimneys. Fill both chimneys with soil. Compact the soil in both. Loosen the top two inches of soil in one chimney. Stand both chimneys in a pan and pour one inch of water in the pan. Note the use of water in the soil.

Table Showing Amounts of Fertilizer

USEFUL FERTILIZER

Name of Vegetable	Suitable Fertilizer	Amount per sq. yd.	When to apply
Corn	Stable manure _____ or _____	10 or 12 pounds	Before plowing or digging
Cabbage			
Cauliflower	Poultry manure _____ or _____	1 pound	After plowing
Eggplant			
Tomato	Commercial fertilizer: Nitrogen 5%, Phosphoric acid 8%, potash 4%	2 ounces	Just before planting
Lettuce			
Peas			
Squash			
Celery			
Melons			
Potatoes	Stable manure _____ or _____	10 or 12 pounds	Before plowing for previous crops
Turnips			
Radishes	Poultry manure _____ or _____	1 pound	Before plowing for previous crops
Beans			
Parsnips	Commercial fertilizer: Nitrogen 2%, Phosphoric acid 8%, Potash 4%	2 ounces	Before planting
Onions			
Carrots			
Oyster Plant			
Beets			
Grapes	Stable manure _____ or _____	10 or 12 pounds	Between the rows in winter
Currants			
Gooseberries	Poultry manure _____ or _____	1 pound	
Rhubarb			
Strawberries	Commercial fertilizer: Nitrogen 4%, Phosphoric Acid 8%, Potash 4%	2 ounces	Before cultivation in spring
Asparagus			

DEVELOPMENT

Experiments 1 and 1-a: (1) Why do farmers dread a dry season, particularly at planting time? (2) Why must we keep cut flowers in water? (3) Why do house plants often wilt in the winter when kept indoors? (4) Why are green houses kept so moist?

Experiments 2, 2-a and 2-b: (1) Why should seeds be tested before planting? (2) What is a "rag-doll" tester and how does it work? (3) About how long can seeds be kept? There are stories of the sprouting of seeds dug from the ruins of ancient cities where they have lain for thousands of years. (4) What truth has science found to this statement? (5) Name four or five seeds that must be barely covered with soil when sown.

Experiments 3 and 3-a: (1) What garden plants are commonly started or multiplied by layering, which is a form of slipping? (2) What can be done to get a large number of trees from one, when the seeds will not come true? Rubber plants do not produce seeds in this latitude. (3) How could new plants be obtained from one of these plants? (4) Why is it better to graft fruit trees than to grow them from seed?

Experiments 4 and 4-a: (1) Why do the roads near the seashore "dry off" so quickly after a rain? (2) Why do sections having an under layer of clay often become swampy? (3) Of what value to plant life is the ability of soil to hold water? (4) Of what value is it to man? (5) How does the proper preservation of trees and other plants help soil to hold water? (6) Name a region where the failure to observe this rule has caused misery and hardship to its people. (7) Why might soil be called the water reservoir of life? (8) What does "fertilize" mean when applied to soil? (9) When do we use fertilizers? (10) What are the three types of soil? (Review Seventh Grade Course, "The Earth's Crust." Experiment 5). (11) Which type of soil is most fertile by nature? (12) In

what way can fertility of the soil be conserved by the proper rotation of crops?

Experiments 5 and 5-a: The water rises in soil by capillarity. (1) What does capillarity mean? (2) What are two illustrations of capillarity about your home? (3) Why do farmers cultivate the soil more often in dry weather? (4) What other useful purpose does cultivation of the soil accomplish? (5) What does irrigation mean when applied to farming? (6) Name a section in your own country which has been made productive by this method. (7) Is soil cultivation required under irrigation? Why?

SUMMARY

In order to sprout seeds must have air, water and warmth. Plants may be started from *seeds*, by *cuttings* or by *grafting*. Many useful plants do not breed true from seed or do not produce seed in our latitude. In such cases new plants are usually obtained by *budding* or by *grafting*.

Because its materials act like a sponge *humus* holds water best. Water is held least of all by *sand* because the *spaces* between the soil *particles* are so large that water flows through them easily.

Soil water contains dissolved *mineral* substances needed by *plants* for food. Soil water when released slowly feeds *rivers* and *streams* used by man. Plant *roots* and leaf carpet help to retain the soil in position and so to conserve our water supply.

Plants, while growing, take *mineral* substances from the soil which man must replenish by adding fertilizers. A good fertilizer must be rich in *nitrogen*, *phosphorus* and *potassium*.

Pulverizing the top layer of soil prevents soil *water* from passing from the soil into the air so easily. Soil cultivation also serves to allow *fertilizers* and *humus* to be more thoroughly distributed to plant roots. It also kills *weeds*.

UNIT VIII

PLANT FRIENDS AND PLANT ENEMIES

GENERAL OBJECTIVES

The objectives are:

1. To appreciate the useful relations between some local plants and animals.
2. The ability to discriminate between helpful and harmful local plants, fungi, insects, toads, and birds.

SPECIFIC OBJECTIVES	PROBLEMS FOR EXPERIMENT	DESIRABLE OUTCOMES
Plant Pests and their Control Weeds	1. Why is it hard to get rid of weeds? (group experiment)	Ability to conclude from directed field work: Why the dandelion, plantain, and wild mustard are classed as weeds.
Molds, Rots and Smuts	2. What makes food substances grow "whiskers"? 2a. What makes apples rot? (class experiment) 2b. From where do molds and rots come? 2c. How can we make some common fungicides? (group experiment)	Knowledge: 1. The role of fungi in causing plant diseases. 2. The facility with which fungi can spread because of their numerous minute spores. 3. The importance of disease control in agriculture.
Insect Pests and Their Control Useful and Harmful Insects	3. How are insects' bodies fitted to their work? (group experiment) 3a. Why are some insects harmful? (group experiment) 3b. How can we make some common insecticides? (group experiment)	Ability to conclude from directed field work: How certain insects by their habits are harmful to man.
Natural Pest Controls	4. Why is the toad called the sentinel of the garden? (group experiment) 5. What are the neighborhood birds like? 5a. How do birds behave?	Knowledge: 1. How toads and birds are useful in controlling weed and insect pests. 2. How best to protect toads and birds.

NOTES ON EXPERIMENTS

Experiment 1 can be performed by examining the root growth and seed production of typical weeds to find out why it is hard to get rid of them. **Experiment 2** can be performed by using the following apparatus and following these directions: 1—Apparatus. Piece of moldy bread, reading glass. 2—Directions and observations: Examine the fuzzy growth of mold under the reading glass. Note the stalk like stems called **filaments**. At the upper end of the filament find the knob like cap, called the **spore case**. From the lower end of the filament note the thread like masses which cover and penetrate the surface of the bread. These threadlike structures serve as roots. They are called **mycelia**. (a) Make an enlarged sketch of 2 or 3 mold plants as you see them under the reading glass. Label correctly the spore case, filament and mycelia. (b) Rub the finger

lightly over the tops of some of the ripe spore cases. Note what comes off. What about the size of these dust like particles? They are the spores which correspond to seeds. You have just studied a member of the **fungus** group of plants. Many members of this family cause rotting of fruit and other plants useful to man. **Experiment 2-a** can be performed by infecting a sound apple with rot from an infected apple and note the result. **Experiment 2-b** can be performed by breaking out the stem from a fresh mushroom and place the cap, gills downward, on a glass plate. Cover with a tumbler. After two days lift cap from plate and note spores. Hold the glass in the sunlight and gently blow across it. Note what happens. **Experiment 2-c** can be performed by selecting one of the preparations listed on the following chart and apply as a spray to some infected plant:

	<i>For Garden and Orchard Use</i>	<i>For Experiment</i>	<i>Directions for Preparing</i>
Lime Sulphur Fungicide For delicate foliage Quicklime Sulphur Water	2 lbs. 2 lbs. 12 gal.	2 gm. 2 gm. 100 cc.	Nearly cover the lime with water. When it begins to slake, add the sulphur. Stir constantly, adding a little water if the mixture becomes too dry. After five minutes add the rest of the water and mix well.
Bordeaux mixture Copper sulphate Quicklime Water	1 lb. 1 lb. 12 gal.	1 gm. 1 gm. 100 cc.	Dissolve the copper sulphate in a glass jar using some of the water. Slake the lime in a tumbler to make a creamy mixture; then add the rest of the water to thin it. Strain this milk of lime through cheese cloth into the copper sulphate solution.

Experiment 3 can be performed by using the following apparatus and following these directions: 1—Apparatus: Large beakers or tumblers covered with netting or cheesecloth held in place by rubber bands; live specimens of butterflies, grasshoppers, bees, beetles, dragon-flies, cicada, or other large insect*; handful of fresh grass or clover; pinch of sugar; reading glass or lens. 2—Directions and observations: Keep the insects in the beakers, having first put in some of the grass or clover. (a) Note the principal color of each insect. Do any of them seem to blend with the grass background in color? The body of an insect is divided into the head, the middle part or thorax, and the abdomen. (b) In which part are found the feelers or antennae; the eyes; the mouth; the legs; the wings? *Movements*—The structure of legs and wings helps an insect to jump, fly, crawl, run, or swim. (c) Let one grasshopper loose in the room. Watch it jump. Note what pair of legs is used, and just how they are used. Using the hand lens, note how the jumping pair of legs differ from the others. (d) Note how many wings the butterfly has. Allow one to fly about the room. Note how many of the wings the butterfly uses when flying. *Feeding*—Insects have either chewing or sucking mouth parts. (e) With lens, examine the mouth parts of the butterfly and the grasshopper. Which kind has chewing and which sucking mouth parts? *Breathing*—Insects breathe through the pores in the walls of the thorax and abdomen. (f) Using the lens, find the breathing pores along the sides of the body of the grasshopper. How many pores are there in each section or segment of the abdomen? *Seeing*—Insects have two large, compound eyes each made up of many simple eyes. (g) Examine one of the compound eyes of an insect through the lens. About what proportion of the head do the eyes cover? **Experiment 3-a** can be performed

by observing a house fly and noting what substances attract them; how they clean their feet. Observe how ants carry aphides to rose bushes. **Experiment 3-b** can be performed by following directions "for experiment" with insecticides listed in the table below.

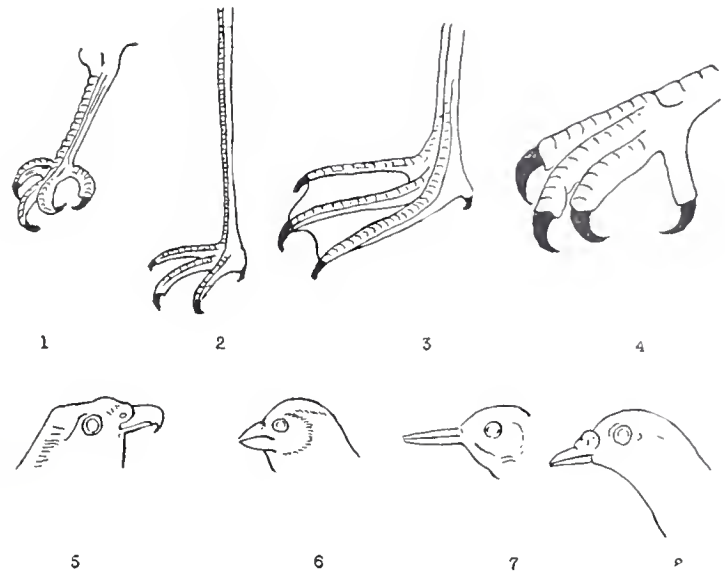


Figure 36

Experiment 4 can be performed by securing a toad. Be sure that the toad is properly protected. Feed it but watch how it eats. **Experiment 5** can be performed by examining carefully pictures of the neighborhood birds. Call attention to such features as are shown in figure 36.

Table Showing Suggested Insecticides

	<i>For garden and orchard use</i>	<i>For experiment</i>	<i>Directions for Preparing</i>
Lime Sulphur Spray For <i>sucking</i> insects Quicklime Sulphur Water	4 lb. 3 lb. 10 gal.	3 gm. 3 gm. 85 cc.	Mix the lime and sulphur in 1/6 the quantity of hot water and boil 1 or 2 hours or until the color becomes a dark amber. Add the remainder of the water. Apply warm.
Arsenate of Lead For <i>chewing</i> insects Arsenate of lead paste Water	1/2 lb. 12 gal.	1/2 gm. 100 cc.	Mix the arsenate of lead paste thoroughly in the water. If powdered arsenate is used, only 1/2 the weight is necessary.
Lime—Paris Green To control potato beetle Paris Green Quicklime Water	2 oz. 1/2 lb. 12 gal.	1/8 gm. 1/2 gm. 100 cc.	Shake the lime to make a creamy mixture, then add more of the water to thin it. Mix the Paris Green with the rest of the water. Strain the milk of lime through the cheese cloth into the Paris Green mixture.
Kerosene Emulsion For plant lice Hard soap Kerosene Water (soft)	1/4 lb. 1 gal. 12 gal.	1/4 gm. 10 cc. 100 cc.	In about 1/20 of the water boiling hot, dissolve the soap. Warm the kerosene and add. Stir vigorously until creamy. Add the rest of the water.

Caution: Arsenate of lead and Paris Green are poisonous and should not be put into your mouth.

*It is best to keep each kind of insect in a separate receptacle.

See table following.

115 Birds to Be Seen in Pennsylvania Each Year
(First Half of Each List Are More Common)

A. Here all year. 1. Starling 2. Flicker 3. Crow 4. Downy woodpecker 5. Song sparrow 6. Screech owl 7. Cardinal 8. Sparrow hawk 9. Cooper's hawk 10. Fish hawk 11. Nuthatch, white breast 12. Cedar waxwing 13. Chickadee 14. Blue jay 15. Carolina wren 16. Purple finch 17. Hairy woodpecker 18. Tufted titmouse 19. Bob-white 20. Goldfinch	D. Due in March. 1. Fox sparrow Tr. 2. Myrtle warbler Tr. 3. Chipping sparrow 4. Swamp sparrow 5. Field sparrow 6. Dove 7. Killdeer 8. Phoebe 9. Kingfisher 10. Woodcock 11. Vulture (Turkey buzzard)	G. Due May 1-15. 1. Catbird 2. Nighthawk 3. Kingbird 4. Orchard oriole 5. Baltimore oriole 6. Wood thrush 7. Veery thrush 8. Yellow throated vireo 9. White eyed vireo 10. Warbling vireo 11. Black hilled cuckoo 12. Indigo bunting 13. Yellow breasted chat 14. Scarlet tanager 15. Humming bird 16. Wood pewee 17. Rose breasted grosbeak 18. Bobolink 19. Grasshopper sparrow 20. Crested flycatcher 21. Red headed woodpecker
B. Here in Winter only. 1. Sea gull 2. Snow bird or junco 3. White-throated sparrow 4. White-crowned sparrow 5. Brown creeper 6. Winter wren 7. Nuthatch, red breasted 8. Golden-crowned kinglet 9. Horned lark 10. Tree sparrow 11. Northern shrike 12. Saw whet owl	E. Due April 1-15. 1. Hermit thrush Tr. 2. Olive backed thrush Tr. 3. Chewink 4. Chimney swift 5. Barn swallow 6. Vesper sparrow 7. Savannah sparrow 8. Martin 9. Ruby crowned kinglet Tr. 10. Green heron 11. Wood duck 12. Yellow palm warbler Tr.	
C. Due in February 1. Purple grackle 2. Robin 3. Bluebird 4. Meadowlark 5. Cowbird 6. Redwinged blackbird 7. Rusty black-bird Tr.	F. Due April 15-May 1. 1. Md. Yellow throat 2. Red-start Tr. 3. Red eyed vireo 4. Solitary vireo 5. Oven bird 6. Yellow warbler 7. Black and white warbler Tr. 8. Pine warbler 9. Blackthroated green warbler Tr. 10. Brown thrasher 11. La. water thrush Tr. 12. Spotted sandpiper 13. House wren 14. Tree swallow 15. Whip-poor-will	Warblers 22. Magnolia 23. Black throated blue 24. Parula 25. Blackburnian 26. Black poll 27. Canadian 28. Prairie 29. Chestnut sided 30. Worm eating 31. Nashville 32. Golden winged 33. Cape May 34. Tennessee 35. Bay breasted 36. Hooded 37. Blue winged yellow 38. Kentucky

NOTE: Almost all the warblers in column 3 and other birds marked Tr. (Transient) stay here only a few days, going north to nest.

No. 26 (column 3) spends the winter in southern Brazil and nests in northern Canada. Look for about one-third of the birds listed here in street and yard trees in your town; the others and perhaps twenty-five more in the country during April and May.

This chart is included for reference. It is not to be made a required assignment for the pupils.

Experiment 5-a can be performed by observing the behavior of the birds studied in experiment 5 as to their feeding habits, movements, haunts, etc.

DEVELOPMENT

Experiment 1: (1) When may plants be called weeds? (2) What harm do weeds do in a flower garden or on a farm? (3) Why are weeds so hard to get rid of? (4) What is the best way of ridding your lawn of weeds like the dandelion and plantain? (Refer to the observations of the experiment.) (5) How can the poison ivy, a weed poisonous to touch, be distinguished from the harmless five-finger ivy?

Experiments 2, 2-a, 2-b and 2-c: (1) Under what conditions will molds and most other fungi grow best? Fungi are said to be either saprophytes or parasites. (2) What does this mean? (3) Are all molds and fungi harmful? Illustrate. (4) Why does an apple rot so readily at a worm hole, cut or bruise? (5) How will a rotten apple or peach affect clean ones when near them? (6) When packing fruit, each fruit is wrapped separately in paper or is packed in straw or sawdust. Why? (7) Why does refrigeration check the spread of fungi? (8) What is mildew? (9) What are some garden plants which it attacks? (10) How can it be controlled? (11) What are rusts? (12) What are some garden plants which they attack? (13) How can plant rust be controlled? (14) What are smuts? (15) What are some garden crops which they attack? (16) How can smuts be controlled? (17) Write for lists of bulletins published by both the State and National governments concerning harmful fungi and their control. With the help of your teacher select those that seem most helpful for your locality. When you receive them discuss them and use the information. (18) Why do people char the ends of fence posts before setting them? (19) Why should lumber be piled away from the ground? (20) Why does a pine stump last longer in a field than a maple or elm stump? (21) Why does a board or shingle rot quickest around a nail? (22) Why should we paint the wound left when a limb is cut off a tree?

Experiments 3, 3-a and 3-b: (1) Literally, what does the word insect mean? (2) Having examined some insects, especially the ants and wasps, how would you account for the selection of this name? (3) Where is the skeleton of an insect found? (4) Is this true of any other animal? (5) Why is it almost impossible to "creep up" on a fly or other insect? (6) Why is the insect provided with this type of protection? Poison sprays are eaten by insects, but powders and soap solutions are not eaten by them. (7) How then do such preparations kill? (8) Would an insect drown if its head were held under water? Why? (9) What insects do you know that have a shape or color that makes them difficult to find in the surroundings where they live? (10) How do insects care for their eggs and young? (11) What methods are best to use in exterminating house flies? (12) Mosquitoes? (13) Clothes moths? (14) Tussock moths? (15) Plant lice? Some insects have natural enemies. (16) In this connection, of what use are dragon flies? (17) Lady-bug beetles? (18) Praying mantis? (19) Birds? (20) Toads? A helpful insect is the honey-bee. (21) How do bees help flowers? (22) How is honey made? (23) For what do bees use honey and pollen? (24) Write for lists of bulletins published by both the State and National governments concerning insect pests and their control. With the help of your teacher select those that seem most helpful for your locality. When you receive them, discuss them and use the information. (25) Why must the eating habits of a harmful insect be known before we can select the proper insecticide? (26) What insects can most easily be exterminated by destroying their breeding places?

Experiment 4: (1) What is there about the toad that probably suggests that he might cause warts? (2) Of what value is it to the toad that he so nearly resembles the background where you find him? Tadpoles live in water. (3) Can they continue to live in water when they become toads? Why? (4) What is the chief distinction between toads and frogs?

Experiments 5 and 5-a: (1) Are all birds useful and friendly? (2) What effect would the destruction of friendly birds have on farm crops? Why? (3) On weeds? Why? (4) On our shade and fruit trees? Why? (5) Which of the five birds you have studied do most people consider least desirable? Why? (6) Which of the birds you have observed are permanent residents? (7) Which ones are summer residents? (8) Why is it that some of these birds do not stay here all year round? Birds may be classified according to their food habits. (9) From the appearances of the beaks in the sketches of Experiment 5 which kind

would be seed eaters? (10) Insect eaters? (11) Birds of prey (feeding on rats, mice, and other birds)? (12) Why is the family cat the most dangerous foe of city birds? (13) How can his bad habits be controlled?

SUMMARY

Weeds are "plants out of place."

Weeds take from the soil *moisture* and dissolved *minerals* needed by cultivated plants. By their numbers they cut off *sunlight* and crowd out useful plants. They are so hardy that they can survive in poor soil; extremes of *cold*, *wet*, and *dry* weather; and injuries that would kill other plants.

Fungi can be spread easily because their *spores* are so tiny that *air* currents carry them great distances. Molds which attack fruits, rusts which attack *fruit* and *grains*, and smuts which attack *grains* are the most harmful types of fungi.

Picked fruits and vegetables can be protected from effects of fungi by *refrigeration* and by wrapping them so they do not touch. All types of fungi can be destroyed on the living plants by *spraying* with fungicides.

Insects Are Well Fitted to Survive

The *hind* legs of the grasshopper are specially designed for *jumping*.

Insects like the *grasshopper* which feed on grass have specially formed *biting* mouth parts. Insects like the *butterfly* which feed on flower nectar have specially formed *sucking* mouth parts.

Many insects are protected from enemies by having their body *color* resemble their *surroundings*.

A toad devours enormous quantities of *insects* injurious to plants. A toad cannot *bite* nor cause *warts* when we handle it.

Bird Recognition

Be able to recognize on sight the English sparrow, common pigeon, starling, grackle, robin, and crow.

Practically all birds are useful. Even the so-called "undesirables" usually do more good than harm. Birds use for food enormous quantities of *insects* and *weed* seeds, which would retard or completely destroy valuable

plants. Birds, by their friendliness, song, and beauty, add *charm* to our everyday life.

Sparrows, originally seed eaters, have learned to use other materials for food. Hence, they can be *permanent* residents. Birds, like robins, require worms which can only be found in soft, unfrozen soil. Hence, they migrate with the season.

Seed eaters have strong, *conical* shaped bills, fitted for cracking seeds. Insect eaters have long, *slender* beaks for getting at insects in crevices. Birds of prey have the upper part of the beak hooked over the lower part, necessary for tearing flesh.

The family cat retains its wild characteristic of eating *birds*. Cats destroy about 80,000,000 birds a year or about 50 birds for each eat. Cats should be *fed* regularly. A *bell* should be fastened about the neck of a cat to warn the birds. Cats should not be let out until late in the morning after they have been *fed*.

Some Harmful Insects

Name of insect	Harmful life stage	Harm it does	Method of control
House fly	adult	spreads disease	Cover garbage and manure where flies breed.
Mosquito	adult	spreads malaria in temperate zones and yellow fever in tropics	Drain swamps or cover with oil.
Tussock moth	larva	eats leaves	Destroy nests on bark of trees.
Clothes moth	larva	destroys woolsens	Clean woolsens before storing them.
Plant lice	adult	weakens plants by sucking sap	Spray with tobacco solution.

Some Useful Insects

Name of insect	Useful life stage	Usefulness
Honey bee	adult	Helps pollinate flowers, makes honey from nectar of flowers makes wax.
Dragon-fly	larva and adult	Eats mosquitoes
Lady-bird beetle	larva and adult	Eats scale insects which destroy fruit trees

NINTH GRADE COURSE IN SCIENCE

UNIT I

THE CHARACTERISTICS OF LIVING THINGS

GENERAL OBJECTIVES

A. To Appreciate the Phenomenon of Life

The phenomenon of life is a subject which is new and fascinating to 9th grade adolescents. The concept to be developed is an appreciation of the importance of the six factors that characterize every living thing, thus marking off the living world from the world without life. We are not studying the complicated structure of the cell nor the theories of metabolism.

B. To Investigate the Nature and Problems of the Living World

The important concepts are three

1. The greatest problem facing living things—to eat without being eaten. The idea of survival.
2. There are ingenious devices in living things for solving the problem. This leads to the principle of adaptation.
3. Living forms are complementary to each other, rather than antagonistic.
This can be illustrated by
 - a. The Oxygen and Nitrogen Cycles.
 - b. The Balance of Nature—a device to keep the numbers of living things from becoming too numerous.
 - c. Reproduction—a device to keep the numbers of living things from becoming too limited.
We are not to study the classification of plant and animal forms, nor to introduce the subjects of mitosis and maturation in connection with reproduction.

SPECIFIC OBJECTIVES	PROBLEMS FOR EXPERIMENT	DESIRABLE OUTCOMES
PART I		
The Living World What Living Things Are	1. How can we know a living thing?	Knowledge:
	1a. Of what is a living body composed? (teacher experiment)	1. The 6 characteristics of living things
		2. Protoplasm is the only substance which is alive.
		3. All living things are composed of cells of protoplasm.
PART II		
How Living Things Begin Life How Plants Begin Life	2. How do seeds begin and grow into plants? (Review 7th Grade Course, "Flowers and Plants," Experiments 1 and 2) (teacher experiment)	4. Each living thing whether plant or animal begins life as an egg cell, which, when fertilized, grows into a new individual.
	3. What is inside a hen's egg?	
How Animals Begin Life	3a. How do living things begin to grow? (group experiment)	
PART III		
Living Things Must Find Essentials for Life The Problem of Food and Air	4. Why do plant roots grow down into the soil? (Review 7th Grade Course, "Flowers and Plants" Experiment 3) (class experiment)	5. Green plants manufacture their own food.
	5. Where do plants make food? (Review 7th Grade Course, "Flowers and Plants" Experiment 5) (class experiment)	6. Food and oxygen are required by all living things.
	6. How are living cells able to absorb food materials? (class experiment)	7. Plants and animals are interdependent with regard to products of respiration.
	6a. How does the blood appear under a microscope? (teacher experiment)	8. Animals must depend on plants for their food.
	6b. How does the blood circulate to and from the body cells? (teacher experiment)	Appreciation of the operation of Nature's great plans among living things.
	7. What gases do plants breathe into the air? (class experiment)	
The Relation Between Plants and Animals	8. How are plants and animals necessary to each other?	

PART IV

How Plants and Animals Maintain Their Kind

The Struggle for Existence

Nature's Camouflage (Adaptation)

Friendly Enemies (The Balance of Nature)

The Continuation of Life (Reproduction)

- 9. What would happen if all the young of a plant or animal should grow? (group experiment)
- 9a. Are all individuals exactly alike?
- 10. What is the advantage of camouflage to living things? (group experiment)
- 10a. Why are all animals not built alike? Report on adaptations of animals seen in the zoo.
- 11. How does nature keep her numbers "balanced"? (class experiment) (Review 7th Grade Course, "Exploring Nature" Experiment 2)

- 12. How are living things formed?
- 12a. How does the pollen nucleus reach the egg cell of a flower? (teacher experiment)

- Knowledge:
- 1. The limitations of food and climate cause a severe competition among living things.
 - 2. Variation and adaptation assist living things to survive in the struggle for existence.
- Appreciation of the fact that
- 1. There is a balance of nature to keep living forms from multiplying too fast and that by an intelligent understanding of this law and by working in harmony with it, man can check the ravages of some dangerous pests.
 - 2. Reproduction is necessary to keep up the races of living things and so to maintain the balance of nature.

PART I—THE LIVING WORLD

EXPERIMENT 1

A. Problem

How can we know a living thing?

B. Experiment

- 1. Apparatus
Any living green plant (in a pot of earth or visible from the window); any living animal (a pet dog or cat or any animal visible from the window).
- 2. Directions and Observations
Observe the plant and animal with reference to the things each requires in order to live.
 - a. Classify these needs according to the following table, stating which parts of the plant and animal body have to do with the satisfying of each need.

Type of Living Thing	Needs
	1.
	2.
	3.
	4.
	5.
	6.

3. Conclusions

How many absolute needs has a living thing? Do plants have exactly the same needs as animals? Make a brief statement about the chief ways in which living things differ from non-living things.

EXPERIMENT 1-A

A. Problem

Of what is a living body composed?

B. Experiment

- 1. Apparatus
Small onion; pair of forceps; scalpel knife; pipette; dilute tincture of iodine; microscope slide and cover; compound microscope.
- 2. Directions and Observations
With the knife and the fingers separate one of the layers of the onion. On the inner surface of

one of these layers find a very delicate, semi-transparent lining. With the forceps remove a piece of this lining. Cut a section of it about 1/4 inch square. Place a drop of water on the microscope slide and in it spread out the square of onion tissue. Place the cover glass over it. Take up any excess water with the edge of a blotter, and with the pipette place a drop of the iodine tincture at the edge of the cover glass so that it may diffuse across the onion tissue.

- a. After a few minutes examine the specimen under the microscope. The little blocks which you see are *cells* composing this particular tissue of the onion. What is the shape of a single cell? Are all the cells the same size? Try to locate the *nucleus* (the stained body in each cell) and the *cell wall* (the membrane surrounding each cell body). The material contained within the cell wall is called *protoplasm*. Count the number of rows of cells in the specimen. In one of these rows count the number of cells. Calculate the approximate number of cells in a square inch of this tissue by using the following formula: number of rows observed x number of cells in one row x 16.
- b. In your observations draw a block one inch square and in it write the result of your calculation.

3. Conclusions

What proof does this experiment give concerning the construction of body tissue in a living organism?

C. Development—Experiments 1 and 1-a

- (1) What is protoplasm? (2) What chemical substances compose protoplasm? (3) If we mixed these substances together could we make a living thing? Why? (4) What do scientists mean when they say that a cell is the unit of a living body? (5) How did the living unit known as a cell get its name? It was formerly thought that non-living material such as decaying vegetation created living organisms. (6) How was this idea disproved? (7) Name a living thing which is composed of a single cell. (8) Why must many-celled living things have their cells organized into tissues and organs? (9) What do biologists mean by "division of labor"?

SUMMARY

All living things must obtain *food* to nourish them, have contact with *oxygen* to release heat and energy, elimi-

nate waste, increase their size by growth, be sensitive to the outside world, reproduce their kind, and move of their own accord.

All living bodies are composed of *protoplasm*. This is the only substance which is alive. This substance is always arranged in *cells*. A living cell is a tiny mass of *protoplasm* containing a *nucleus* and usually surrounded by a *cell-wall*.

Characteristics of Living Things

Requirements	Use
1.	
2.	
3.	
4.	
5.	
6.	

Reports

Louis Pasteur and Spontaneous Generation
Reference: F. L. Darrow "Masters of Science and Invention," page 191

PART II—HOW LIVING THINGS BEGIN LIFE

EXPERIMENT 2 (teacher experiment)

- A. Problem
- How do seeds begin and grow into plants?
- B. Experiment
- Review "Experiment" and "Summary," 7th Grade Course, "Flowers and Plants," Experiments 1 and 2.
- C. Development (after "Conclusions" of Experiment 3-a)

EXPERIMENT 3

- A. Problem
- What is inside a hen's egg?
- B. Experiment
1. Apparatus
- A fresh egg; sealpel or poeket knife; beaker.
2. Directions and Observations
- a. Gently shake the egg to find out whether the contents are firmly or loosely packed.

With the handle of the sealpel or knife carefully craek into fine pieeces a portion of the shell on the larger end of the egg. With the finger nail remove a few of the tiny pieces in such a way that the membrane beneath will not be broken.

b. Examine this membrane noting whether it is tougher or more delicate in strueture than the shell. This lining serves as a protection against germs.

c. Remove suffieient of the shell and lining to obtain a good view of the interior. Note the position of the yolk and white.

d. Empty the contents of the shell into the beaker taking eare not to break the yolk. Confirm the relative position of the yolk and white. The yolk is very nearly as fluid as the white. How does this explain the relative position of the parts?

e. Examine the yolk until you find a small white spot. This is the real egg from which the *embryo* (the new individual) will develop.

3. Conelusions
- Make a ehart which will show the parts of the egg and their probable uses.

EXPERIMENT 3-A

- A. Problem
- How do living things begin to grow?
- B. Experiment
1. Apparatus
- Fresh eggs of the frog; about 1 quart of pond water; 7 white dishes (soup plates); reading glasses; covers for the white dishes.
2. Directions and Observations
- a. Placee some of the eggs in each dish in pond water. Note the proteeting jelly coat on each egg.

b. Observe the eggs through a reading glass from day to day to see the different stages of development of the new individual (the embryo). (Add water daily and cover to prevent drying up.) Do you find any that consist of a single large egg eell? Do any show by depressions or furrows around them that they have divided, first into 2 eells, then into 4 eells, then into a larger number of cells? Do you find any that have beecome elongated instead of spherieal?

c. Observe these elongated embryos from day to day. Can you distinguish the formation of the head and tail in any of them? Can you distinguish eyes and other organs in any of them? After the young animal frees itself from the surrounding jelly, it swims through the water and attaches itself to floating objects or to the walls of the dish.

d. Note how many days were required for the egg to develop to this swimming or "tadpole" state.

e. With the glass, observe the sides of the tadpole body near the eye. Fringe-like organs found here are *gills* (breathing organs).

3. Conelusions
- In answering the problem question explain what happened within the egg that started it to develop into the embryo, and the ehanges which took place as this grew.

- C. Development—Experiments 2, 3, and 3-a
- (1) So far as function (use) is concerned, what similarities are there between the parts of a plant seed and the parts of an animal embryo?

(2) From what does the plant embryo secure its food while sprouting?

(3) From what does the embryo within the animal egg secure its nourishment?

(4) What conditions are necessary for a seed to sprout?

(5) Why will eggs usually not hatch after they have been subjected to sudden and great changes in temperature?

(6) Will cold storage eggs usually hatch? Why? Why are plant seeds and the eggs of fowls such perfect foods for man?

SUMMARY

How Living Things Begin Life

Each *living* thing begins life as a single cell, ealled the egg-cell. After the egg-cell is *fertilized*, the new individual, ealled an *embryo*, begins to grow. This *fer-ti-lized* egg-cell *divides* to make new *cells*.

How Plants Begin Life

The *fertilized* egg-cell divides many times to form the seed, or plant *embryo*. A mature plant grows from a *seed*. In each seed are the *radicle*, *plumule*, and *cotyledons*. The young plant secures its first nourishment from or through the *cotyledons*.

How Animals Begin Life

Every one of our common animals grows from a *fertilized* egg-cell. This egg-cell divides and forms the animal *embryo*. The bird embryo gets its nourishment from the *yolk* and "*white*" of the *egg*.

How Living Things Begin Life

<i>Plant World</i> (Parts of a bean seed)	<i>Similarity</i> <i>of Function</i>	<i>Animal World</i> (Parts of a hen's egg)
1. Tough outside seed coat		1. Shell or tough outside membrane
2. Lining membrane		2. Lining membrane
3. Embryo		3. Embryo
4. Food in cotyledons		4. Yolk and "white"

Reports

Make a report upon plant seeds and animal eggs used by man for food and other purposes.

PART III—LIVING THINGS MUST FIND ESSENTIALS FOR LIFE**EXPERIMENT 4 (class experiment)****A. Problem**

Why do plant roots grow down into the soil?

B. Experiment

Review "Experiment" and "Summary," 7th Grade Course, "Flowers and Plants," Experiment 3.

C. Development

- (1) How is a growing root able to push its way through the soil? (2) Does a root grow along its entire length? Explain. (3) What advantage is it to the plant for root hairs to grow out from all sides of the main (tap) root? (4) Explain all the ways in which roots serve plants. (5) When will it be necessary for roots to penetrate deeply into the soil? (6) When will they spread out widely?

EXPERIMENT 5 (class experiment)**A. Problem**

Where do plants make food?

B. Experiment

Review "Experiment" and "Summary," 7th Grade Course, "Flowers and Plants," Experiment 5.

C. Development

- (1) What is chlorophyll? (2) What is the purpose of this substance in leaves? (3) Why must a tree have a trunk and branches? (4) What is the reason for the definite arrangement of leaves on plants? (5) How is this accomplished by trees and other large plants? (6) Why is starch thought of as a storage form of plant food and sugar as a transportation form? (7) Where do plants store food? (Recall 7th Grade Course, "Exploring Nature," Experiment 5.) (8) Do animals also store food? If so, in what form? (9) When pests like the grasshopper or Japanese beetle devour the leaves from cereal plants, the grain is not developed, no matter how favorable the climate or soil. Why?

EXPERIMENT 6 (class experiment)**A. Problem**

How are living cells able to absorb dissolved food materials?

B. Experiment**1. Apparatus**

Thistle tube thrust through a 1-hole stopper; burette clamp and iron support to hold the tube; piece of sausage skin or gold beater's skin about 2 inches square; about 1 foot of strong thread; molasses solution made by mixing 2 tablespoonfuls of molasses with 1 tablespoonful of water; small beaker half filled with water.

2. Directions and Observations

Hold the thistle tube with the bowl end up. Close the lower end with a finger, and let your neighbor fill the bowl with the molasses solution, allowing it to flow down the stem for about one inch. (This can be regulated nicely by carefully permitting a little air to escape from the lower end of the tube.) When the bowl is completely filled have the membrane stretched rather tightly over its end and securely tied about the rim with the thread.

a. Now invert the tube and fasten it to the iron support by means of the burette clamp. Set the beaker of water under the tube and lower it into the water until the bowl is covered. Note the height of liquid in the tube and then set the apparatus aside where it will not be disturbed.

b. At the end of 1 hour, 4 hours, and 24 hours make observations of the height of the liquid in the tube.

c. At the end of 24 hours taste the liquid in the beaker to find out whether the molasses has been able to pass through the membrane into the water of the beaker.

This experiment illustrates the process known as *osmosis*. By this method an interchange of solutions takes place through the membranes of all plants and animal cells.

3. Conclusions

Was the greater movement of liquid toward the denser solution in the tube (the molasses) or toward the water in the beaker?

In a science textbook read about the process of osmosis. Then explain how this experiment illustrates the way living cells are able to absorb food materials. Mention which part of the apparatus represents the cell wall; the protoplasm; the dissolved food materials outside the cells and the sap-carrying tubes.

C. Development (after "Conclusions" of Experiment 6-b)**EXPERIMENT 6-A (teacher experiment)****A. Problem**

How does the blood appear under a microscope?

B. Experiment**1. Apparatus**

Needle; Bunsen burner; piece of absorbent cotton wet with alcohol; compound microscope; microscope slide; cover glass with thin coat of vaseline around its edge; pair of forceps; salt solution.

2. Directions and Observations

Sterilize the inner surface of the first joint of the ring finger on the left hand with alcohol (on cotton). Sterilize a needle by holding the point in the Bunsen flame for a few seconds. After the alcohol has dried from the finger, press the tip against the end of the thumb, and pierce the skin with the needle by a quick tap. Touch the

center of the slide with the drop of blood, add a drop of salt solution*, and place the cover glass. Press carefully around the edge so as to seal it.

- a. Place the slide under the low power and then under the high power. Note particularly the shape and color of the corpuscles of the blood and their arrangement.

3. Conclusions

What does the blood seem to consist of? In what part of the blood is most of the coloring matter?

C. Development (after "Conclusions" of Experiment 6-b)

EXPERIMENT 6-B (teacher experiment)

A. Problem

How does the blood circulate to and from the body cells?

B. Experiment

1. Apparatus

Live tadpole about 1 inch long; small piece of soft cloth or cotton; microscope slide; compound microscope.

2. Directions and Observations

Wet the soft rag or cotton with water. Wrap the body of the tadpole in it in such a way that the tip of the tail is exposed. Lay the animal on the microscope slide.

- a. Under the low power observe the blood corpuscles flowing through the arteries, capillaries, and veins, along the edge of the tail of a tadpole. (After the experiment, unwrap the tadpole and return it to the aquarium).

3. Conclusions

In answering the problem question include the following: Does the blood flow steadily or by "pulsations" through the arteries? Why? Through the veins? Why? Does it flow more slowly through the capillaries than through arteries or veins? Why? Where are arteries placed? Why?

C. Development—Experiments 6, 6-a, and 6-b.

- (1) Why will sprinkling the ground with salt water destroy the weeds? (2) Why will dried fruits, like prunes, swell up when placed in fresh water, but shrink when placed in salt water? (3) Why is the elaborate process of digestion necessary in animals and not in plants? (4) Which part of the blood carries the nourishment to animal tissues? (5) Of what use are the red corpuscles in the blood? (6) Why is it that plants do not require bodies like red corpuscles? (7) How is plant nourishment carried about throughout the plant structure? The white corpuscles and fibrin forming material also exist in the blood, although not seen in Experiment 6b. (8) What is the importance of each? (9) The fluid part of the blood is called plasma. It contains the serum. (10) Of what importance is this?

EXPERIMENT 7 (class experiment)

A. Problem

What gases do plants release into the air?

B. Experiment

1. Apparatus

Battery jar filled with water; 4-inch glass funnel; 6-inch test tube; carbon dioxide generator (see 7th Grade Course, "Fire—Friend and Foe," Experi-

ment 5); 2 tablespoonfuls of baking soda; 50 cc. of dilute hydrochloric acid; green aquarium plant; wood splint, match.

2. Directions and Observations

First, strongly charge the water in the jar, with carbon dioxide from the generator. Place the aquarium plant in the bottom of the jar of charged water. Invert the funnel over the plant. Fill the test tube with water from the jar and invert it over the stem of the funnel.

- a. Place the apparatus in strong sunlight. After about $\frac{1}{2}$ hour note the bubbles of gas being given off by the plant and collecting in the test tube.

Allow the apparatus to remain undisturbed (perhaps for a day) until an inch or so of gas has collected in the test tube. The formation of this gas is always a by-product of food making.

- b. Carefully remove the test tube, keeping it *mouth downward*. Light the wood splint. When it is burning well, blow out the flame so that a glowing spark remains. Thrust this glowing end of the splint well up into the tube of gas. Note the effect. What gas reacts in this way?

3. Conclusions

What gas product is given off by green plants in the daytime? Why? (Recall Experiment 5.)

C. Development

- (1) What other gases besides oxygen do plants release into the air? (2) During what part of the day does this take place? Why? (3) What other gas besides oxygen and carbon dioxide do plants and animals give off into the air?

EXPERIMENT 8

A. Problem

How are plants and animals necessary to each other?

B. Experiment

1. Apparatus

Charts of the *Carbon Oxygen Cycle* and of the *Nitrogen Cycle*.

2. Directions and Observations

- a. Carefully study the following chart:

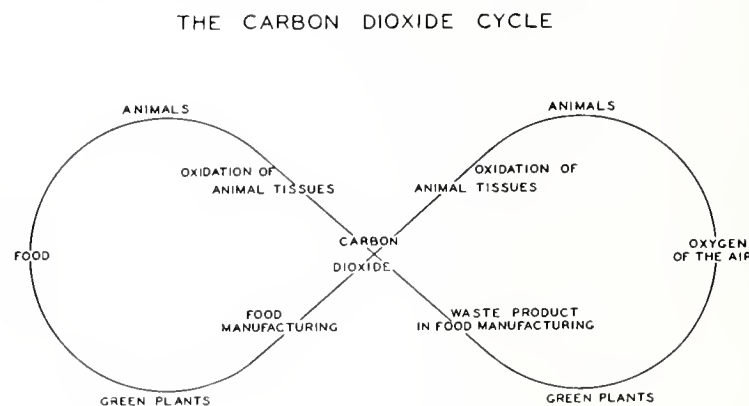


Figure 37

In writing your observations begin with the animals. Where do the animals obtain oxygen? What happens to the oxygen within their bodies? As what product does it leave the animal body? What use do the plants make of this product? What use

* Make salt solution in the proportion of 1 gram of salt to 30 cc. of water. This salt solution can be bottled and kept indefinitely.

do animals make of it? What product do plants release back to the air?

b. Carefully study the following chart:

THE NITROGEN CYCLE

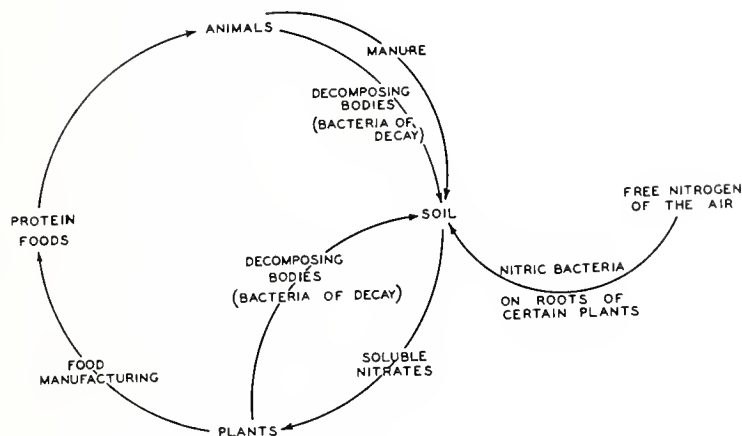


Figure 38

Begin with the plants. Where do the plants obtain their nitrogen substances? What do they make from them? In what form does the nitrogen get into the animal body? In what forms is the nitrogen returned to the soil from the bodies of plants and animals? What causes this material from the plants and animals to become usable again by plants? How do green plants get the free nitrogen from the air?

3. Conclusions

In answering the problem question explain: What plants and animals do for each other with regard to the air mixture. What plants and animals do for each other with regard to food relations.

C. Development

- (1) Do plants ever get hungry? (2) What is the essential difference between plant food and animal food? (3) In what ways are food materials used to satisfy the needs of plants and animals? (4) In what sense is chlorophyll sometimes called "the magician food maker of the world"? All animals are dependent upon plants for food. (5) Explain how meat-eating animals like the lion, wolf, and cat can be dependent in any way upon plants. (6) For what purposes do plants and animals require food and contact with oxygen?

SUMMARY

Green plants are able to manufacture food in their leaves by combining *dissolved* soil minerals with *carbon* from carbon dioxide in the air in the presence of *sunlight*. In this process *oxygen* is given off to the air as a by-product.

Root *hairs*, by the process of *osmosis*, absorb the *dissolved* soil minerals into the plant. By the same process *food* materials are passed into the *cells* of all plant and animal structures.

All animals must take in *oxygen*. This is carried to the body cells by the *red corpuscles* of the *blood* in higher animals. Plants carry on *respiration* both day and night.

Food is required by living things to provide *heat* and *energy*; to provide for the *repair* of *used* tissue and to provide material for new *growth*.

Oxygen is required by living things to liberate *heat* and *energy* by oxidizing the *food* materials and the worn out *tissue*. The by-products given off to the air by this oxidation are *carbon dioxide* and *water*.

Plants and animals are *interdependent*. Plants give off *oxygen* to the air which animals need while animals give off *carbon dioxide* to the air which plants require.

Animals must depend on *plants* for the *manufacture* of all their food materials.

REPORTS

PART IV—HOW PLANTS AND ANIMALS MAINTAIN THEIR KIND

EXPERIMENT 9 (group experiment)

A. Problem

What would happen if all the young of a plant or animal should grow?

B. Experiment

1. Apparatus

Ears of corn or milkweed pods or pods of fresh peas; data concerning the eggs of sparrows and frogs.

2. Directions and Observations

- a. By counting the number of rows of seeds on the ear of corn or within the milkweed or pea pod and the number of seeds in one row, calculate the number of seeds produced. Assuming that each seed produces one plant and that each plant will develop one ear or one pod like your sample, calculate the descendants in the tenth generation.
- b. One female house fly usually lays 120 eggs which grow to adults in 10 days. Suppose in each generation all the eggs would hatch and half of them be females. At that rate how many flies might be produced from a single pair during 4 summer months?
- c. Suppose one frog lays 10,000 eggs all of which hatch, and that half of the young are females; calculate the total number of frogs at the end of 10 generations from this single female, assuming that no frogs die and that all the eggs hatch.

3. Conclusions

According to your calculations how must you answer the problem question?

EXPERIMENT 9-A

A. Problem

Are all individuals exactly alike?

B. Experiment

1. Apparatus

About 2 cupfuls of dried lima beans; rule; piece of string about 15 inches long.

2. Directions and Observations

Each student will make a random selection of 5 lima beans.

- a. Measure the longest dimension of each bean to the nearest sixteenth of an inch.
- b. Compile the class results and fill in the following chart:

	Lengths of lima beans					
	Up to 4/16"	5/16"	6/16"	7/16"	8/16"	9/16" etc.
Number of beans						

- c. With the aid of the string carefully measure the circumference of your left wrist. (It is best to have your neighbor measure your wrist and for you to measure his.)

- d. Compile the class results and tabulate them on a chart similar to the one above.
- 3. Conclusions
Are all individuals of the same group alike? In the struggle for existence suppose the greatest variation in a given characteristic proved to be most advantageous, what do you think would result: With regard to members of the group now living? With regard to the future generations of the group if this characteristic is inheritable?

C. Development—Experiments 9 and 9-a

- (1) What is meant by the struggle for existence among living things? (2) What are some reasons why living things do not increase as rapidly as the calculations of Experiment 9 would suggest? A pair of quail ate over 1500 beetles in one day. (3) What significance has this fact in the struggle for existence? Suppose the struggle for existence should become inoperative. (4) What result would you predict upon the earth? Sturgeon and shad lay millions of eggs each year. (5) Is there any value to man in this overproduction? Make a study of several plants growing in a vacant lot. (6) What evidences of the struggle for existence can you find? (7) Does the struggle for existence operate in the human family? (8) If so, are its effects most noticeable among savage or civilized man? (9) What has the inheritance of variations in the characteristics of living things suggested to scientists like Charles Darwin? (10) How has man made use of the principle of selection in this respect? (11) Who has done the most along this line to improve our food plants in America?

EXPERIMENT 10 (group experiment)

- A. Problem
What is the advantage of camouflage to living things?
- B. Experiment
 - 1. Apparatus
White potatoes of various sizes (4 potatoes of each size); whiting (liquid "shoe polish"); dark colored ink; paint brush; water.
 - 2. Directions and Observations
The potatoes are to represent "animals." In each series leave one potato natural in color. Paint the whole surface of one potato with a diluted ink solution. Paint half of each of the other 2 potatoes dark, and the other half white.

One member of each group will place the 4 "animals" in a row (not too closely together) at the end of a corridor illuminated by artificial light or, better, outdoors, in a good sized open space. Observers must not watch while this is being done. Place one of the half-dark "animals" with the dark surface down, and the other one with the dark surface uppermost. Observe the groups of "animals" at distances of 10 feet, 50 feet, 100 feet, 200 feet, noting at each distance the visibility of each "animal" as conspicuous, inconspicuous, or hidden.

a. Record your observations in a chart like this:

Distance	Color scheme of animals			
	Entirely dark	Entirely light	Dark below	Dark above
At 10 feet				
At 50 feet				
At 100 feet				
At 200 feet				

- 3. Conclusions
Was the same animal most conspicuous both when you were close and when you were at a distance? Explain why one animal showed up less prominently than any of the others? This scheme in nature has been called the protective coloring adaptation. How can you explain the advantage of camouflage or protective color to living things? (In a textbook see "Adaptation" to help you.)

EXPERIMENT 10-A

- A. Problem
Why are all animals not exactly alike?
- B. Experiment
 - 1. Apparatus
A live cat; deer at the zoo. (Pictures can be used.)
 - 2. Directions and Observations
The cat family illustrates *carnivorous* animals (those which prey upon other animals for food). The deer family illustrates *herbivorous* animals (those which use only plants for food).

a. With regard to both types of animals make the following studies:

(1) The legs and feet. Note which type has claws; foot pads; hoofs. Note the relative length of the legs, i.e., whether the animal's body is relatively close to the ground or not. Note also the comparative thickness of the leg.

(2) Mouth parts. Observe whether the teeth are flat or pointed. Note also whether the tongue is large and muscular or thin and flat. Observe the motion of the jaws while in action whether they move vertically or in a horizontal-rotary fashion. Note which type chews its food more thoroughly. Arrange your results according to the following chart form:

Type of animal	Legs and Feet			Mouth Parts		
	Length of leg	Thick-ness of leg	Foot parts	Shape of teeth	Shape of tongue	Motion of jaws

- 3. Conclusions
Herbivorous animals fear carnivorous animals because the former are food for the latter. From your observations of the leg and foot parts of each type which will be able best to spring up and run? Why? Which will be able best to creep and leap? Why? Why will such action be necessary in the life of each type? How will hoofs be of most use in one type and claws and foot pads in the other?

Do plant stalks or animal flesh have tough woody fibers enclosing the nourishing substances? From your observations of the mouth parts which type of animal would need to grind its food into small pieces for proper digestion? In what ways are mouth parts and motions of the jaws best adapted for their purpose in each type? In a textbook see "Adaptation." In what ways does this experiment illustrate the principle?

C. Development—Experiments 10 and 10-a

- (1) What birds or mammals do you know that are lighter beneath and darker above? (2) What is there about their habits that would explain the usefulness of their coloring? (3) What adaptations of structure can you find in your own body? (4) For what use does each seem to be? (5) What adaptations do you know that occur in insect life?

(6) How can you explain this statement: "The great problem in nature is to eat without being eaten in turn." (7) How does adaptation help in solving this problem? (8) List some adaptations among plants and animals which assist them to obtain food. (9) List some adaptations among plants and animals which assist them in escaping those who would eat them. (10) List some adaptations among plants and animals that protect them against climatic conditions such as low temperature, high temperature, desert conditions.

FIELD EXCURSION—Report on Adaptations of Animals Seen in the Zoo

- (1) What carnivorous animals did you see? With reference to carnivorous mammals: (2) Why has the lion a fairly even colored tawny coat, while the tiger has a striped coat and the leopard a spotted coat? (3) What adaptation has the seal for its environment? (4) What adaptation is provided to keep water from entering the nostrils of the seal? (5) What herbivorous animals did you see? (6) What adaptations for securing food did you see among the herbivorous animals? (7) What adaptations did you list that assisted the bird, mammal, or reptile in capturing its prey? With reference to herbivorous mammals: (8) Why has the giraffe a spotted coat while the zebra has a striped one? The giraffe feeds upon the leaves of trees. (9) What adaptations are provided in body structure to assist it? (10) Why has the elephant a dark grey colored coat? (11) What adaptations of the foot and leg structure help the elephant to travel easily upon swampy ground? (12) In what ways is its trunk useful?

EXPERIMENT 11 (class experiment)

A. Problem

How does nature keep her numbers "balanced"?

B. Experiment

1. Apparatus

Small glass aquarium or battery jar; about 2 cupfuls of mud from a creek or pond; 1 or 2 bunches of aquarium plants; about 1 large cupful of clean gravel; sufficient water from the creek or pond to nearly fill the aquarium*; 1 or 2 goldfish; water snail; tadpole; pane of glass large enough to cover the open top of the aquarium.

2. Directions and Observations

Spread the mud over the bottom of the aquarium and scatter the gravel over the mud. Carefully pour in the pond water. Lay the plants in the water and introduce the water animals.

a. Set the aquarium in a light place. Note whether the animal life seems to show evidences of annoyance or distress.

b. Remove the plant life. After an hour or two note what the fish and tadpoles are forced to do every few moments. The aquarium life is now in an *unbalanced* condition.

c. In the mud plant the aquarium vegetation. Cover the aquarium with the pane of glass to prevent evaporation. Observe from time to time what the animals are doing. Note whether their behavior seems to be normal and contented or disturbed. The aquarium life is now said to be *balanced*.

d. Carefully watch the animals to see how they feed and what they eat.

3. Conclusions

Recall Experiment 8. How do you account for the behavior of the animal life before and after removing the plant life from the aquarium? What other waste materials will the animals give off that will be useful to the plants? When is the life

in an aquarium called *balanced*? How can the balance be upset? What would happen then? Referring to your textbook compare life on the earth to a balanced aquarium. How does nature keep her numbers "balanced"?

C. Development

- (1) Explain how the balance of nature keeps living forms from multiplying too fast. (2) How is the balance of nature illustrated by the food habits of insects like the grasshopper and birds such as the meadow lark? (3) How are tussock moths held in "check" by nature's method? (4) What is the natural "check" for mosquitoes? (5) What arguments in favor of conservation of wild life, particularly of birds and toads, can you give as a result of your study of the balance of nature? Man in his ignorance sometimes disturbs the balance of nature. (6) How has this been illustrated by the Japanese beetle introduced into New Jersey in 1915? (7) What other examples of this disturbance can you give? Recently man has been able to control injurious pests by introducing the natural "check." (8) How is this illustrated in the orange growing industry of our own country?

EXPERIMENT 12

A. Problem

How are living things formed?

B. Experiment

1. Apparatus

Accompanying figures 39, 40, and 41.

2. Directions and Observations

- a. Study drawing marked "Reproduction in Higher Plants." What is the male reproductive cell called? From what organ does it come? What is the female reproductive cell called? In what organ is it found? What must the male and female reproductive cells do in order for fertilization to take place?

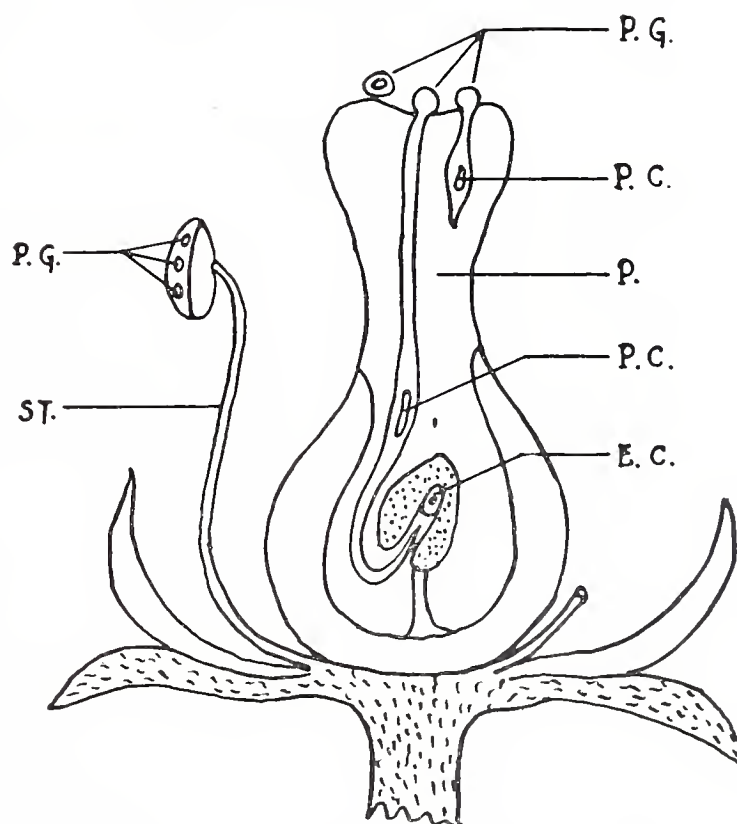


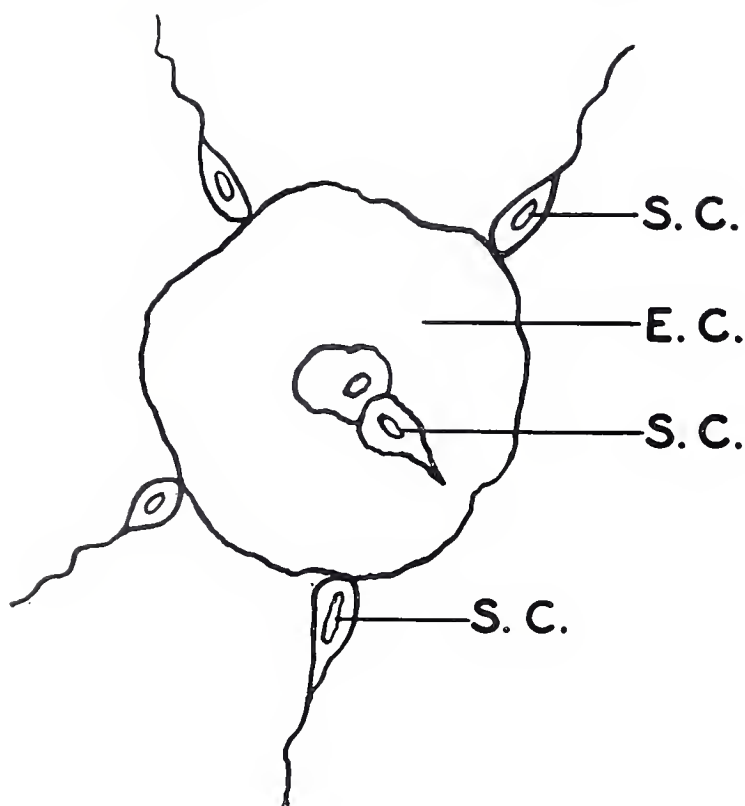
Figure 39. Reproduction in Higher Plants

P. Pistil
ST. Stamen
P.G. Pollen Grains

P.C. Pollen Cell (Male Reproductive Cell)
E.C. Egg Cell (Female Reproductive Cell)

* Do not use water from the faucet since the chemicals used in it to kill bacteria are injurious to aquarium life.

- b. Study drawing marked "Reproduction in Higher Animals." What is the male reproductive cell called? What is the female reproductive cell called? What must the male and female reproductive cells do in order for fertilization to take place?



KEY

E.C.—EGG CELL (FEMALE REPRODUCTIVE CELL)
S.C.—SPERM CELL (MALE REPRODUCTIVE CELL)

Figure 40. Reproduction in Higher Animals

- c. Study drawing marked "Reproduction in One-Celled Plants and Animals." What gradually happens to the original parent cell in order for a new individual to be formed?

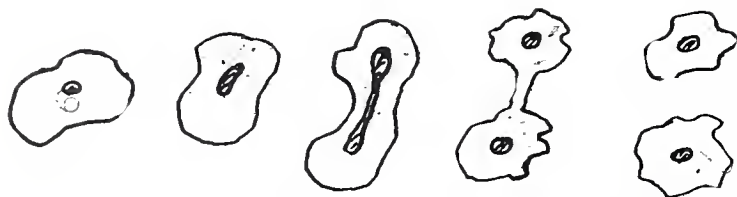


Figure 41. Reproduction in One-celled Plants and Animals

3. Conclusions

How many reproductive cells are required in the reproduction of higher plants and animals? What must these reproductive cells do to form a new individual? What process is followed by one-celled plants and animals in forming new individuals?

D. Development (after "Conclusions" of Experiment 12-a)

EXPERIMENT 12-A

A. Problem

How does the pollen reach the egg cell of the flower?

B. Experiment

1. Apparatus

Pollen from some of the following flowers: snap dragon (butter and eggs), sweet peas, tulip, nasturtium; sugar solution (3 per cent, 10 per cent, 15

per cent); large beaker; moist sponge; reading glass; compound microscope.

2. Directions

- a. Dust some ripe pollen on one of the glass slides. Examine it with the reading glass.

Dust some ripe pollen on a drop of sugar solution placed on the other glass slide. (Use the 10 per cent solution with snap dragon pollen, 15 per cent solution with sweet pea or nasturtium pollen, 3 per cent solution with tulip pollen.) Place the slide under the large inverted beaker with the moist sponge for 24 hours.

- b. Examine the pollen culture after 24 hours under the low power of the microscope. Look for tube-like structures (the *pollen tubes*). Describe them.

3. Conclusions

What made the pollen grow? How does the male reproductive cell in pollen tubes reach the egg cell of a flower? (Recall Experiment 12.)

C. Development—Experiments 12 and 12-a

- (1) From your knowledge of the struggle for existence and the balance of nature explain why reproduction is necessary. (2) What does the enormous reproductive rate of lower forms of life suggest to you? (3) How do you explain the fact that higher organisms do not need to reproduce so rapidly?

SUMMARY

There tends to be an *overproduction* of plants and animals in nature. The limitations of *food* and *climate* cause a severe competition among living things.

No two living things are exactly *alike*. Some of these *variations* among living things seem to help them *survive* in the struggle for existence. Those that *survive* tend to pass on these valuable qualities to their *offspring*.

Adaptation is a *change* in the *body* structure of a plant or animal which helps it to *survive*. Adaptations may assist living things to obtain *food*, escape their *enemies*, and resist *climatic* conditions.

Nature tends to keep living things from *multiplying* too fast by having one form of *life* depend upon another for *food*. By *destroying* certain forms of *wild* life man often *upsets* the balance of nature. The *Japanese* beetle has been able to *multiply* so rapidly in the eastern United States because of the absence of its natural *enemies*. By introducing its natural *enemy* scientists are often able to *check* the ravages of a dangerous *pest*.

The Continuation of Life

The object of reproduction is to keep up the *numbers* of nature's living things. In *one* celled plants and animals reproduction is accomplished by simple *division* of the parent cell. In higher forms of plants and animals *two* reproductive cells must *unite* to form a new individual.

Reports

Charles Darwin, Alfred Wallace, Gregor Mendel

Adaptation of animals seen in the Zoo.

NOTE ON METHOD

Experiment 1: (1) Only one set-up of apparatus is necessary. Pupils should form a line and pass before the microscope to make their own observations. (2) Never permit pupils to touch or adjust the microscope. (3) In counting the cells in the specimen, time may be saved by having a committee of two do this part and report to the class.

Experiment 6-a, 6-b, 12-a: Pupils should form a line and pass before the microscope to make their own observations.

UNIT II

COMMON ELEMENTS AND COMPOUNDS

GENERAL OBJECTIVES

A. Mixtures and Compounds

The concept to be developed is that the earth's crust is composed of many different substances. Some of these are mixed together mechanically (without changing their original properties and composition). Others are combined chemically. Many of these can be torn apart and recombined so as to increase their usefulness. Do not introduce the complications of atomic theories nor valence in these lessons.

B. Useful Elements and Compounds

The object is merely to acquaint the pupil with a few of the most common substances.

SPECIFIC OBJECTIVES	PROBLEMS FOR EXPERIMENT	DESIRABLE OUTCOMES
Mixtures and Compounds Mixtures and Solutions	1. What happens when we mix substances together? 2. Why is alcohol used to "thin" shellac and Carbona to remove grease spots? (group experiment) 2a. What happens if we keep adding sugar to a fixed amount of water? (group experiment) 2b. What is a supersaturated solution? 2c. What happens when lye and washing soda are exposed to the air?	Knowledge: 1. Mixtures retain the original properties of the substances used. 2. Solutions are really mixtures of solutes and solvents. 3. Some substances lose water (effloresce) and others absorb water (deliquesce) when exposed to the air. 4. Every chemical compound is a union of 2 or more elements to form a new substance with new properties.
A Chemical Compound	3. What is a chemical compound? 4. Of what is water made? (teacher experiment)	
Some Elements and Compounds Useful in Industry and in the Home Useful Elements and Compounds	5. What is oxygen like? 6. What can oxygen do? (teacher experiment) 6a. How can we make ink eradicator? 7. What is hydrogen like? (teacher experiment) 7a. What is the easiest way to clean silver? 8. Why is carbon such an important element? (group experiment)	5. Oxygen is essential to life, and is used in industry. 6. Hydrogen is a constituent of most fuel substances. 7. Carbon is important because it exists in so many useful forms, and in certain very dangerous substances, such as carbon monoxide.
Sour Substances, Bitter Substances, and Salty Substances Acids Bases	9. Why is vinegar sour? 10. Why has lye a soapy feel?	8. Common acids, bases, and salts are used in industry and the home. 9. Acids and bases neutralize each other.
Salts and Neutralization	11. Why does ocean water taste salty? 11a. What happens when an acid and a base are put together? 11b. How can we make soap?	10. Acids, bases, and salts can be easily distinguished and the simple methods by which this is done.

NOTES ON EXPERIMENTS

Experiment 1 can be performed by noting the effects of the bar magnet on a mixture of sulphur and iron filings. Likewise, take the same mixture and add water. After shaking, note which settles to the bottom. **Experiment 2** can be performed by using the following apparatus and following these directions: 1—Apparatus: Three four-inch test tubes; twenty cc. each of water, alcohol and tetrachloride (Carbona); nine flakes of dry shellac or three pieces of rosin each the size of a very small pea; three pieces of paraffin each the size of a very small pea; nine flakes of iodine. In one of the test tubes place iodine, in the other place shellac, in the other paraffin. Add about ten cc. of water to each and shake for about a minute. Note whether any of the solids have been dissolved. Repeat the experiment using alcohol instead of water. Then repeat the experiment a third time using carbon tetrachloride instead of

alcohol. **Experiment 2-a** illustrates the making of diluted, concentrated and saturated solutions. To 5 cc. of water in a test tube add successive 2 cc. portions of sugar until a total of 12 cc. has been used. Heat the test tube as the solution becomes more concentrated. **Experiment 2-b** can be performed by heating a six inch test tube one fourth full of hypo crystals until they dissolve. Cool and throw in a crystal of solid hypo. **Experiment 2-c** can be performed by placing in separate water crystals, small portion of lye and washing soda. Expose to the air for a day or two. **Experiment 3** can be performed by taking 4 cc. of fine iron filings and 6 cc. of powdered sulphur and heating until the mixture glows like a hot coal by deflecting the Bunsen flame upon it. Crush part of the cinders and note the effect of the magnet upon it. Take another pinch of this mixture in a dry test tube and apply the water test as in experiment 1. **Experiment 4** can be performed by using the Brownlee form of electrolysis apparatus in a

battery jar of acidulated water and applying D. C. electricity. **Experiment 5** can be performed by placing some mercuric oxide into a test tube very carefully by means of a paper trough. While the mixture is being heated over the Bunsen flame another pupil can prepare a glowing splint. Note the reaction when this is placed far down into the test tube. The residue in the tube is mercury; the gas produced was oxygen. The method you have used to obtain the metal mercury is called reduction. **Experiment 6** can be performed by setting up the apparatus as suggested in diagram 42 and proceed as follows: Mix 9 cc. of potassium chlorate and 3 cc. of manganese dioxide well and introduce the mixture into the test tube with the paper trough so that the material lies diagonally in the test tube. (See drawing). Fasten the test tube in the burette clamp and attach the one-hole stopper and delivery tube. Gently heat the mixture by brushing the Bunsen flame across it until bubbles of gas issue from the delivery tube. (Be careful to heat evenly and not at one point.) When the gas is generating rapidly, lift one of the jars from the bottom of the tank and place it on the metal strip over the delivery tube. Remove the flame from the test tube. Renew the heating only when the bubbling seems to slacken too much. At no time should the gas be permitted to escape too vigorously nor should it at any time be permitted to cease entirely. When this jar is completely filled with gas, remove it by slipping a glass plate over the open end and set aside on the table. Fill the other two jars with gas in a similar manner. Immediately disconnect the delivery tube by pulling out stopper from the test tube. Slip the glass plates sufficiently aside from each jar for a moment to pour in a handful of sand. Replace the glass plates. (a) Pick up a half inch piece of charcoal with tongs and heat it in the Bunsen flame until it glows. Slip the glass plate sufficiently aside from one of the jars of gas to introduce the tongs with the glowing charcoal. Note any differences in the burning of charcoal in the air, and in this gas. What is this gas? (b) Fill a deflagrating spoon with sulphur. Ignite the sulphur with the Bunsen flame. When it is burning well, slip the glass plate aside sufficiently from the second jar of oxygen to introduce the burning sulphur. Note any differences in the burning of sulphur in the air and in pure oxygen. (c) Fray out one end of an 8 inch piece of iron picture wire and bend it to a right angle. Heat the frayed end of the iron wire and dip it into some sulphur. Ignite the sulphur which adheres to the wire and plunge this end into the third jar of oxygen. Describe what takes place. **Experiment 6-a** can be performed by making Javelle water in one beaker and a ten percent solution of hydrochloric acid in another. White with ink on a paper and apply with a glass rod first the Javelle water and then the acid solution. **Experiment 7** can be performed by setting up the apparatus as suggested in figure 43 and proceed as follows: Put a handful of mossy zinc in the flask and add sufficient water to cover it. Set up the apparatus as shown in drawing. Wrap the flask in a wet towel. Do not have any flame nearer than three feet when generating hydrogen. This is most important. (a) Pour some hydrochloric acid into the thistle tube. Note what happens inside the flask and at the end of the delivery tube. (The substance being generated is the element hydrogen.) Note whether hydrogen is a gas, a liquid or a solid and observe its color. Allow the hydrogen to bubble through the water for at least one minute. Raise the test tube filled with water from the bottom of the tank and invert on the metal strip, over the delivery tube. When filled with gas remove it from the tank, being careful to keep the test tube in an upright position while handling it. (b) Holding the test tube away from you bring the open end near the Bunsen flame. Does hydrogen burn? (c)*

* How to Light Hydrogen Safely. The gas should be evolving rapidly. If necessary the flow of gas may be hastened by adding a few drops of copper sulphate solution to the contents of the flask. Put a dry test tube over the outlet tube for one full minute, then carry the tube, open end downward, to the Bunsen flame, at least 3 feet away. If the test tube of gas ignites with a "pop" air is still mixed with the hydrogen. Test until the hydrogen burns quietly.

Fill a dry test tube with hydrogen. Ignite it as in "b". Note what was formed on the inside surface of the test tube. Immediately disconnect the stopper from the flask and wash the contents well with water. The zinc may then be returned to the stock bottle. **Experiment 7-a** can be performed by dissolving in a large beaker one tablespoonful of washing soda in one-half pint of hot water. Drop a small piece of sheet aluminum or zinc into the beaker. Place a piece of tarnished silver in the solution. Then let the silver touch the aluminum which still is in the solution. Note differences in effect. **Experiment 8** can be performed by examining coal, coke, charcoal and graphite noting how they differ in color, luster and hardness. Study the effect of heat upon these. Examine cornstarch after being heated in a Bunsen flame until no smoke is given off. Note the substance deposited on the bottom of an evaporating dish when lowered into the flame of a burning splint; also, describe the deposit when a cold dish is lowered into the yellow flame after the holes at the base of the Bunsen burner have been closed. Do the same in a lighted candle flame. Note the color of cider vinegar. Filter it into a test tube. Note any change in the color. Fill a test tube one-fourth full of animal charcoal; add the vinegar. Shake this mixture and warm with a low flame for about five minutes. Filter. Note the color of the vinegar. The following charts may be used as aids in recording observations:

Forms of Carbon	Color	Luster	Hardness	Ease of Burning	Gas or Smoke	Flame	Ash

Name	Physical State	Burns	Supports Burning	Important Uses of Elements or Compounds
Oxygen				
Hydrogen				
Carbon				

Experiment 9 can be performed by using the following apparatus and following these directions: 1—Apparatus: Three small beakers; about fifteen cc. of hydrochloric acid; two cc. of tartaric acid; about fifty cc. of vinegar; three strips of red litmus paper, three strips of blue litmus paper; six pieces of mossy zinc; stirring rod; water, match. 2—Directions and observations: (a) Place each of the acids in beakers and add fifteen cc. of water to each. Note whether these three materials are soluble in water. (b) By using the tip of the little finger not the characteristic taste of each substance. (c) Put the end of one of the red paper strips into the hydrochloric acid. Note any color change. Repeat for the other two acids. (d) Place two pieces of zinc in each of the beakers and note what occurs. A certain gas is released whenever any acid reacts with this metal because it is present in every acid. What gas is this? (Recall Experiment 6.) **Experiment 10** can be performed by using the following apparatus and following these directions: 1—Apparatus: Three small beakers; piece of potassium hydroxide about one-half inch long; about twenty cc. of ammonia water; about twenty cc of limewater; three strips of blue litmus paper; three strips of red litmus paper; stirring rod; water. 2—Directions and observations: (a) Note whether the potassium hydroxide, the ammonia water, the lime-water are each soluble in water. (b) Note the characteristic taste of each. (Recall Experiment 9.) (c) Rub a little

of each substance between the thumb and finger. Note the feeling. (d) Note any color change on the litmus paper in each. **Experiment 11** can be performed by using the following apparatus and following these directions: 1—Apparatus: Three small beakers; about five cc. of sodium chloride; five cc. of potassium chloride; five cc. of sodium sulphate; strip of red litmus paper; strip of blue litmus paper; stirring rod; water; pipette full of phenolphthalein solution. 2—Directions and observations: (a) Place the sodium chloride in one beaker, the potassium chloride in another, and the sodium sulphate in the third one. Examine and describe each of the substances. (b) Add about 25 cc. of water to each beaker and stir. Note whether the three materials are soluble in water. (c) Taste each of the substances in the same way that you did the acids in Experiment 9. Taste only very weak solutions of any salt. None in the solid form except table salt. Note the characteristic taste of each substance. Test each salt solution with litmus papers and phenolphthalein solution. **Experiment 11-a** can be performed by dissolving one-fourth inch piece of lye in 10 cc. of water in an evaporating dish. Save a few drops of this solution in a test tube. To the remainder add a few drops of phenolphthalein solution and with a pipette add dilute hydrochloric acid, drop by drop, until the solution is colorless. This process is known as **neutralization**. Evaporate the solution until a powder appears. Add water and note the taste. **Experiment 11-b** can be performed by placing two level teaspoonfuls of animal or vegetable oil dissolved in alcohol in an evaporating dish. Add 3 cc. of a 33% water solution of lye. Warm the dish gently stirring with a wood splint until the mixture is of the thickness of a stiff batter. Place a little of this substance in a test tube, add water and shake.

the shape of the crystallized form of a substance help you identify the substance? Why? (14) How are jewels formed in the earth? (15) What relation has pressure to the solubility of gases in liquids? (16) How is commercial soda water made? (17) Is this solution supersaturated or concentrated? (18) Why are crackers less crisp in the open than in a tight box? (19) Why do doors often fit too tightly in summer? (20) How can you explain the action of a "humidor" in keeping cigars and tobacco in proper condition? (21) Why does candy become sticky in damp weather? (22) Why does salt "cake" and pour less easily in damp weather? (23) Is it more economical to buy washing soda before or after it has been exposed to the air for a time? Why?

Experiment 3: (1) In two columns, one marked Physical Change, the other Chemical Change, list the following in their proper place: cutting an apple, burning a match, a broken pitcher, chopping wood, boiling water, iron rust, candle burning, snow melting, burning paper, hardening of paint, fermenting of fruit juices. (2) Does a chemical change destroy matter? (3) What are the three states of matter? (4) If a substance is changed from one state to another is the change physical or chemical? (5) What is alchemy? (6) What was the main result of the labors of the alchemists? (7) What does a scientist mean by an element? (8) About how many elements are present in the earth? (9) How many elements did the ancients think were present? (10) What were they? (11) What was the last element discovered? (12) What is the spectroscope? (13) How is it used in the study of elements? (14) Why do scientists use symbols when referring to elements? (15) For what elements do you know the symbols? (16) Divide the common elements which you know into three classes: solids, liquids, gases. (17) Which are most

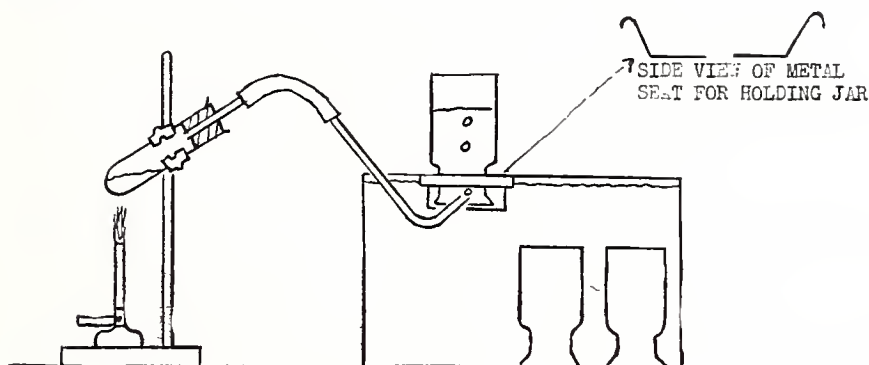


Figure 42

DEVELOPMENT

Experiment 1: (1) What mixtures can you name among substances found in your home? (2) Air is a mixture of what gases? (3) What sort of a mixture is a suspension? (4) How would you separate substances in suspension? (5) What sort of a mixture is an emulsion? (6) What type of mixture is muddy water? (7) Mayonnaise? (8) A cup of cocoa? (9) What is an alloy? (10) What are some common alloys?

Experiments 2, 2-a, 2-b and 2-c: (1) What is the most universal solvent? (2) What solvent is used most frequently in preparing medicines and extracts? (3) Is it good to drink water with your meals? Why? (4) How do you explain the change in the color of water while making coffee in a percolator? (5) Why will soaking with water remove a stamp from a letter? (6) Is water safe to drink because it is clear, colorless, and odorless? Why? (7) How would you show that any natural water is really a dilute solution? (8) Why does sugar dissolve more quickly in hot coffee than it does in iced tea? (9) Why does a solution of iodine become stronger if the stopper is left out of the bottle? (10) Why does sugar collect around the mouth of the syrup jug? (11) Why do you beat fudge as it cools? (12) Do all crystals have the same shape? (13) Would

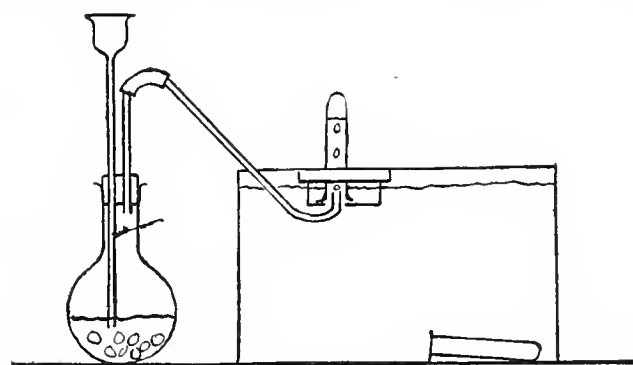


Figure 43

numerous in the earth, compounds or elements? (18) Write the names of three compounds found in the home; in industry; in the science laboratory?

Experiment 4: (1) In what industrial processes is electrolysis used? (2) What is meant by cathode? (3) What is meant by anode? (4) Is matter ever destroyed? (5) Is the statement "There is nothing new under the sun" a true one? (6) What is meant by the law of definite proportions as related to chemical compounds? (7) What is the significance of the suffixes "ite" and "ate" in the names of chemical compounds? (8) Judging from the names of the following compounds tell what elements are in each: lead sulphide, copper sulphate, iron oxide, sodium chloride, potassium chlorate.

Experiment 5: (1) Name other methods of preparing oxygen not mentioned in the experiment. (2) What has the fractional distillation of liquid air to do with oxygen? (3) How do our hospitals make use of oxygen? (4) How is oxygen made use of in industry? (5) Explain the slogan used by paint dealers: "Save the surface and you save all." (6) What is the cycle through which oxygen passes in nature? (7) How is oxygen used in the reduction of metals from ores? (8) What relation has oxygen to fire? (Recall 7th Grade Course, "Fire, Friend, and Foe," Experiments 1

and 3.) (9) Why are the names of Joseph Priestley and Antoine Lavoisier associated with oxygen?

Experiments 6 and 6-a: (1) Is chlorine ever found free in nature? (2) What is a halogen? (3) What use was made of chlorine in the World War? (4) Find out the uses of the following chlorine compounds in the home and in industry: hydrochloric acid, Dakin's Solution, Javelle water, chloroform, chloride of lime, sodium chloride, ammonium chloride (sal ammoniac), potassium chlorate.

Experiments 7 and 7-a: (1) How do chemists explain the removal of tarnish by the method used in Experiment 7a? (2) How are silver-backed mirrors made? (3) What is meant by silver plating? (4) What other metals besides silver are commonly used in electroplating? The chemical elements are divided into metals and non-metals. (5) Find a definition of each. (6) Name some non-metals. (7) Could we electroplate a non-metal?

Experiment 8: (1) How many forms of the element carbon can you name? (2) Which is the hardest form? (3) For what purpose is this form used in the home? (4) In industry? (5) Under what conditions is graphite used as a lubricant? Why? (6) Why is graphite so useful in stove polish? (7) What are some practical uses of charcoal? (8) What role does carbon play in the iron industry? (9) What two other elements combined with carbon are always found in living matter? (10) What are some uses for the following carbon compounds: ethyl alcohol, methyl alcohol, carbon disulphide, carbon tetrachloride (Carbona), sodium carbonate, sodium bicarbonate, calcium carbide, carborundum? (11) What are some sources of carbon dioxide? (Recall 7th Grade Course, "Fire—Friend and Foe," Experiment 5). (12) Explain in what ways carbon dioxide is essential to life? (13) With the enormous consumption of carbon dioxide by plants, why is the supply of this gas in the air not greatly reduced? (14) What is the role of carbon dioxide in extinguishing fire? (15) Why is carbon monoxide such a dangerous gas? (16) What are the two chief sources of it? (17) What precautions can be taken to avoid it? After an explosion in mines, men may be suffocated by "choke damp." (18) What is "choke damp"?

Experiment 9: (1) Name three foods containing acids. (2) What acids are commonly used in laboratories and industries? (3) What acids are used about the home? (4) Are all acids safe to taste? (5) What effect have strong acids upon clothing? (6) Upon flesh? (7) What is "acid mouth"? (8) List some acids which are solids; some which are liquids; some which seem to be gases. (9) What acid is formed in the stomach of man and some animals? (10) Of what use is it there? Galvanized iron is iron covered with zinc. (11) Can galvanized iron pans be used safely for cooking acid fruits? (12) Why are acids used in "etching" metals? (13) What gas is always liberated when acids react with carbonates? (14) With zinc?

Experiment 10: (1) How many bases can you name? (2) What is the most common base in nature? (3) Name at least two substances used in the home that are bases or alkalis. (4) Why should blankets never be washed in lye water? (5) What is a lime kiln? (6) How is commercial lime prepared? (7) What is quick lime? (8) What is the difference between air slaked and water slaked lime? (9) What is plastering, or "white coal"? (10) What is mortar? (11) How is it prepared? (12) What use is made of lime by farmers and gardeners? (13) Why is limestone used in a blast furnace? (14) What is the chemical explanation of the formation of limestone caverns? (15) What are stalactites? (16) Stalagmites?

Experiments 11, 11-a and 11-b: (1) What is the most common salt used in the home? (2) Name other substances used in the home that are salts. (3) Name substances used in industry that are salts. (4) How is table salt produced commercially? (5) How do scientists explain the formation of salt caves? (6) Why do salt lakes like the Gr at Salt

Lake and the Dead Sea contain so much salt? (7) How may the destructive quality of an acid be counteracted? (8) How can you cause the sourness of an acid to disappear? (9) If you spilled some acid on your hand what would you use to counteract it? (10) If you burned yourself with lye what would you use? (11) How could you remove the effect of acid fruit stains from fabrics? (12) Why is baking soda effective when placed on a bee sting? (13) How would you sweeten sour milk? (14) Why does the farmer use lime to sweeten sour soil? (15) How may acid stomach be corrected? (16) What is an indicator as applied to acids, bases, salts? (17) What other indicators are there besides litmus? (18) How does each react in the presence of an acid? (19) A base? (20) A salt? (21) How would you test a "soda mint"? (22) "Milk of magnesia"? (23) Why is each useful? (24) Why may soap be classed as a chemical salt? (25) If lye is the base what sort of substance must the fat be in the process of soap making? (26) How did our colonial ancestors make the chemical base or alkali or "lye" needed for soap making? (27) What is the meaning of potash? (28) "Leach water"? (29) What is soft soap? (30) How is it made? (31) What valuable by-product comes from soap making? (32) What are some of its uses? (33) Why is the use of perfume or disinfectants in soap always suspicious? (34) How does soap make us clean? (Recall 7th Grade Course, "Making Use of Water," Experiment 4.)

SUMMARY

When two or more substances are *mixed* together in such a way that each substance *retains* its *original* properties a mechanical mixture has been formed.

A solution is a uniform *mixture* that will not separate on long *standing* or on being passed through a *filter*. Substances able to dissolve other substances to form solutions are termed *solvents*. The most important solvent is *water*.

A substance that is able to dissolve in a *solvent* is called a solute. The amount of a solute in a given quantity of a *solvent* causes a solution to be either *dilute*, *concentrated*, or *saturated*.

Efflorescence occurs when substances *lose* water when exposed to the *air*. Hygroscopic substances *absorb* water when exposed to the *air*. Deliquescent substances *absorb* sufficient water to dissolve when exposed to the *air*.

When two or more substances *unite* to form a *new* substance with properties *different* from those of the original substances a chemical compound has been formed.

An element is a substance that has resisted all the usual methods of *changing* it into a *simpler* substance. The *earth*, *sun*, and *stars* are composed of the same elements.*

Elements unite or recombine to form *compounds* in *definite* proportions which are always *fixed* for any given compound.

Three of the most important elements are *oxygen*, *hydrogen*, and *carbon* because they are essential to the life of every plant and animal cell.

In addition, oxygen is important because it supports *burning*. When it unites with other substances the process is called *oxidation*. Oxidation always liberates *heat*. Oxygen is a powerful bleaching agent and disinfectant at the moment it is *liberated* from a compound. Chlorine is important in a bleaching compound because it serves to *release* the oxygen.

Hydrogen is important because it is a constituent of *illuminating* gas and other *fuels*. Because of its *lightness* it is used to inflate balloons and zeppelins.

Carbon is important because it is found in so many *forms* and has so many *uses* when alone, or combined. The

* We cannot study the composition of the other members of the solar system, since they are not incandescent.

element carbon exists as the *diamond*, *graphite*, *coal*, *charcoal*, *lampblack*. Combined with hydrogen it is a constituent of all substances used for *fuels*.

One of the most dangerous compounds of carbon is carbon monoxide because it is *colorless*, *odorless*, and *poisonous*. It is a product of the *coal* fire and of the exhaust from *auto engines*.

Acids are compounds which have a *sour* taste, and which turn litmus *red*. They all contain *hydrogen*. Acids attack *zinc* liberating *hydrogen*. Many acids destroy the materials of *bone*, *flesh*, and *cloth*. In the home, acids are found in *vinegar*, *fruit* juices, and in *sour* milk. The

most important acids used in industry are *sulphuric*, *hydrochloric*, and *nitric* acids.

Bases or alkalies are compounds having a *bitter* taste, a slippery feel, and turn litmus *blue*. Bases destroy the materials of *flesh* and cloth made from *animal* fibers. They change *grease* into soap. In the home, *ammonia* water is the most common base. The most important bases used in industry are *sodium hydroxide* and calcium hydroxide or slaked *lime*.

A salt is the neutralized result of an *acid* with a *base*.

Salts are compounds which have a *salty* taste. The most common salt is *sodium chloride*.

UNIT III

LIGHT

GENERAL OBJECTIVES

A. Light Enables Us to See Objects

The objectives are, to show that light waves and rays move according to definite laws. Two of these types of movement, *reflection* and *refraction*, make it possible for us to see objects by making use of lenses, properly illuminate our homes and places of work and recreation. We are not to study the theories of light nor the mathematics of its motion.

B. The Application of Light Effects in the Worthwhile Use of Leisure Time

The object is to acquaint the pupil with the use of the photographic camera, the use of "blue print" and other light-sensitive paper.

SPECIFIC OBJECTIVES	PROBLEMS FOR EXPERIMENT	DESIRABLE OUTCOMES
What Light Reveals to Us How Light Travels	Review 7th Grade Course, "What the Sky Gives Us," Experiment 5.	Knowledge:
Reflection	1. What happens when a beam of light strikes a mirror? (group experiment) 1a. Why do we see images in a mirror? (group experiment) 1b. What objects can we see? (class experiment)	1. Light travels in straight lines. 2. Light rays can be thrown off of a surface (reflection) or bent as they pass through a medium (refraction).
Refraction	2. What happens when light passes from water into air? 2a. How do lenses seem to bring objects nearer? 2b. What makes the rainbow? (class experiment)	3. The spectrum and the rainbow are produced by refraction. 4. Only objects that are luminous or that are able to reflect light can be seen. Appreciation of the reason for the great variety of color in nature and art.
How Light Can Be Used Illumination	3. How near should the source of light be for reading or working? (class experiment) 3a. Where should the source of light be for reading or working?	Knowledge: 1. Diffused illumination is easier on the eye. 2. Lights should be placed behind and to the left of the reader or worker.
Photography and the Camera	4. How does light print a picture? (group experiment) 4a. How does a pin hole camera work? (class experiment) 4b. How does a kodak camera work? (class experiment)	3. Photography depends upon the fact that certain silver salts are sensitive to light. 4. The camera "focuses" the light by refracting the rays as they pass through a lens, and regulates the amount of light that falls on the sensitive plate. Appreciation of: 1. The necessity of securing proper illumination for the care of eyesight. 2. The beauty of nature revealed by light. 3. The skill of the artist in using color.

NOTES ON EXPERIMENTS

Experiment 1 can be performed by using a piece of cardboard large enough to cover the lower square of the window pane; small mirror; sufficient chalk dust or talcum powder to cover a ten cent piece; wide rule or narrow strip of stiff paper; white card 3 x 5. When no sunlight is available, use a lantern, covering the lens aperture with a pasteboard through which a small hole has been punched. Proceed with the experiment as follows: (a) Fasten the cardboard securely in the window. Punch a $\frac{3}{16}$ inch hole near the center of the lower half of the cardboard. Draw the shades of the room. Hold the mirror in the hand so that the beam of light strikes it. With the mirror inclined at about a thirty degree angle note what happens to the beam of light after it strikes the mirror. A greater effect is noted if the powder is spread thinly on the rule or stiff piece of paper and blown across the two beams of light. (b) Note the various effects when the mirror

is rotated and held at different angles. (c) With the pencil held at right angles to the surface of the mirror where the light beam strikes it, note the relation between the angle and the angle at which it is reflected. (d) Can you hold the mirror so that the reflected beam will shine back into the punched hole from which it originally came? Remove the mirror and replace it with the white card. (e) Hold the card at a thirty degree angle. Can you now get a spot of light reflected on the ceiling? Blow some powder between the card and the source of light. Compare the result with the similar operation performed with the mirror. State in which case the reflected light beams are parallel. **Experiment 1-a** can be performed by placing a ruler on a table with the "1-inch" mark against a vertical mirror. At the "4-inch" mark place a lighted candle and at the "8-inch" mark place a book. Note the appearance of the images and how far behind the mirror the images seem to be. Apply the two laws of reflection in obtaining the conclusion. **Experiment 1-b** can be performed

by draping a piece of black velveteen over a pile of books to form a background. Have a small ball covered with a piece of the black velveteen. In front of the left hand edge of the black cloth background place a lighted candle about 3 feet from the observer. Two feet to the right of the candle on the cloth shelf, place in a horizontal row a potato, a polished apple and the cloth covered ball. Darken the room. Note the visibility of the various articles. Before drawing a conclusion look up **luminous** and **non-luminous** and review law of reflection. **Experiment 2** can be performed by placing a lead pencil at least six inches long in a glass tumbler of water. Note the difference in the appearance of the pencil above the water line and beneath the water. Also a coin may be placed in a tea cup so that it is just out of sight. Without moving the eye pour water into the cup. Note what happens with regard to the coin. **Experiment 2-a** can be performed by using a convex lens to form an image of the window frame on a piece of white cardboard. Note size and appearance of image. Hold one convex lens with the left hand at arms length. Look through it at the window with the right eye. Place another convex lens near the right eye. Look through both lenses at the window. Move the lens in the left hand back and forth until image is clear. Compare naked eye with view through both lenses. **Experiment 2-b** can be performed by filling a Florence flask with water and allow a beam of light to pass through it and be refracted upon a piece of white cardboard. The flask of water represents the effect of a single drop of rain water in producing a rainbow. **Experiment 3** can be performed by using the following apparatus: Candle or flashlight; piece of cardboard 8 by 10 inches in which a hole one inch square is cut; piece of cardboard eighteen inches square; meter stick. Proceed as follows: (a) In a darkened room place a candle or flashlight one foot away from a one-inch square hole in a cardboard. Place a large white cardboard upright two feet away from the candle. (b) Measure the space lighted by the rays of light which pass through the hole. (c) Move the white card three feet away from the source of light. Again measure the space lighted by the rays of light. (d) Record the observations by filling in a table similar to the one following:

<i>Distance from light</i>	<i>Area of illumination</i>
2 feet	sq. in.
3 feet	sq. in.

Experiment 3-a can be performed by placing a reading lamp in various positions with relation to the body. Note the illumination on a book or other piece of reading material for each position of the light. **Experiment 4** can be performed by using the following apparatus and following these directions: 1—Apparatus: One quarter ounce of silver nitrate crystals; clean evaporating dish or Syracuse watch glass; beaker containing about 250 cc. of distilled water; tablespoonful of common salt; seven or eight 2-inch squares of soft, unglazed paper; key or button. 2—Directions and observations: Place two tablespoonfuls of distilled water in the dish and dissolve in it the silver nitrate crystals.* Dissolve the common salt in the water remaining in the beaker. Soak the squares of paper in the salt solution. Drain them and then lay them flat upon the silver nitrate solution until a thick white forms. (a) Lay the prepared papers film side up in strong sunlight and immediately cover a portion of each with a key or a button. Note what happens to the paper. (b) When the exposed parts are thoroughly darkened, remove quickly to a shaded place and examine. **Experiment 4-a** can be performed by making a pin hole camera and observe the image.

Experiment 4-b can be performed by examining a box camera and a folding kodak identifying the shutter, diaphragm, lens, light proof box, and film holder. Use the textbook description to aid you in identifying the parts and learning their uses.

DEVELOPMENT

Experiments 1, 1-a and 1-b: (1) Why do traffic policemen wear white caps, white cuffs, and white capes at night? (2) Explain the white marking at dangerous automobile curves. (3) What is a heliograph? (4) How could you brighten up a back room whose windows face a blank wall? (5) What is "camouflage" as used in warfare? (6) How could you construct a homemade periscope from two pocket mirrors and a mailing tube? (A sketch is helpful). (7) What are some uses of a periscope? (8) Where is the best place to fix a mirror on an automobile? Why? (9) How does the operator of a bus count his passengers without turning around? (10) What is the real shape of the crescent moon? (11) Why can we not see the stars in daytime? (12) How are marionettes operated? (13) How can illusions such as ghost dancers on the stage be produced? (14) How are numerals on some watches made readable in the dark? (15) Are "opaque, buff-colored window shades" properly named? Why? (16) When are translucent window panes used in building construction? (17) What is Florentine glass? (18) What was used for window panes in the Middle Ages? (19) Was this material translucent or transparent? (20) When you read this sentence, do you see the black letters or only the white paper around them?

Experiments 2, 2-a and 2-b: (1) How does a fish in the water see the fisherman first? (2) Why is the sun visible after it is actually set? (3) What does refraction mean when applied to light? Recall 7th Grade Course, "What the Sky Gives Us." Experiment 5-a, and answer the following questions: (4) What are the colors in sunlight? (5) What is a rainbow? (6) Do objects really have the color in themselves? (7) What has occurred when we say an object has a "red" color? (8) Why is the sky blue? (9) What is a "black" substance? (10) Under what conditions will an object be "white"? The shape of the surface of a lens gives it its name. (11) How many of these shapes can you name? (12) How many things can you name in everyday life which make use of the lens? (13) Name as many scientific instruments as you can that make use of the lens. (14) What is an expert on lenses called? (15) What is a spectroscope? (16) What use does the chemist make of it? (17) What use does the astronomer make of it?

Experiments 3, and 3-a: (1) What is snow blindness? (2) What causes it? (3) Why is it necessary to wear dark glasses at the sea shore? (4) What does the scientist mean when he says that a light is of a certain "candle power"? (5) How should desks be placed with reference to the windows? (6) Should a baby's crib face the window? (7) Should a baby's coach be turned toward the sun or away from the sun? (8) Why should we not gaze at the sun or other strong light with the naked eye? (9) How does an automobilist protect his eyes against glare? (10) What should be the position of a bed in regard to the window? (11) Is your bedroom properly lighted? (12) Give five rules we should observe to prevent eye strain. (13) Should a mirror be hung where the light will fall upon it, or upon the person using it?

Experiments 4, 4-a and 4-b: (1) What material is used to coat a photographic film? (2) Light of what color only is safe to use when working with unexposed photographic film or paper? (3) What is a photographic negative? (4) Can the image on an exposed film or plate be seen? (5) What is meant by "development"? (6) What is meant by a "fixing"? (7) In what respect is the eye similar to a camera? (8) How do objects look in both the camera and the eye? Account for this. (9) How many images focused in the eye?

* Silver nitrate solution will stain the fingers.

SUMMARY

Light always travels in *straight* lines.

Reflection is changing the *original* path of light by having it *strike* a reflecting *surface*. Reflected light rays from flat *polished* surfaces leave in parallel lines. Reflected light rays from *unpolished* surfaces leave in various directions.

Refraction is changing the *original* path of light, by passing it from one *substance* into another *substance* which is denser or rarer than the first. When refraction bends light sufficiently, it separates the *colors* which compose it. This produces the *spectrum*. The rainbow is the spectrum of *sunlight* produced by the *refraction* of light through *rain* drops.

We can see only those objects that are *luminous* or that are able to *reflect* light.

Convex lenses can be used to *enlarge* the *image* of objects and to bring them *closer* to us.

Light direct from *luminous* bodies or from *polished* surfaces is harmful to the eye because it is too *intense*. The easiest light upon the eye is *diffused* illumination.

Lights should be placed behind and to the *left* of the reader or worker. A shade should be used which will allow the light to fall on the *work* but keep it out of the *eyes*.

The exposure of a film is regulated by the size of the camera's *diaphragm* and the length of time the *shutter* is kept *open*.

In a negative the blacks and whites of the original *object* are *reversed*, but in the finished print they are the *same*.

The taking of a picture depends upon the fact that certain substances like *silver* salts are *sensitive* to *light*, and deposited by it.

UNIT IV

MEASUREMENTS AND CALCULATIONS

GENERAL OBJECTIVES

A. Appreciation of the fact that

1. An individual's untrained sensory equipment is unreliable.

Some constantly "over-estimate" while others "under-estimate" in their judgment of space relations.

All individuals have this "personal equation."

2. This "personal equation" persists even when using measuring devices.

An individual can develop a technique in using measuring devices which reduces this "error" to a minimum.

3. By practice one's senses may be trained to a remarkable degree in accurately judging measurements.

B. Practice in measuring and using measuring devices

"Practice makes perfect," therefore many opportunities are offered for measuring. Experiments under "Measuring Volume and Density" are not to be used to develop the theory of Archimedes nor the principles of buoyancy. They are offered so as to give additional types and opportunities for practice in measuring.

SPECIFIC OBJECTIVES	PROBLEMS FOR EXPERIMENT	DESIRABLE OUTCOMES
Why We Need Measuring Devices Our Ability to Measure	1. Do my eyes and fingers tell me the exact truth?	Convictions: 1. Unaided personal observations are unreliable.
How to Improve Our Measuring Ability	2. How accurately can I measure?	2. Errors in measuring are reduced by using the "average" of many observations.
Measuring and Calculating English-Metric Equivalents	3. What is the metric equivalent of an inch? 3a. How long is a one-hundred-meter dash? 3b. If the American soldiers purchased ice cream in France at \$1.00 per liter how much would they pay for a quart? (group experiment)	3. Metric calculating is easy because it is based on the decimal system. Knowledge: 1. The metric units for weight, length, and volume are, respectively, the gram, meter, and liter.
Measuring Volume and Density	4. How heavy is a pound (avoirdupois) in metric units? (group experiment) 5. How can we measure the volume of a stone of irregular shape? (group experiment) 5a. Is it easier to lift a stone in the air or under water? 5b. Why does wood float and marble sink in water? (group experiment)	2. The metric system is used by scientists, in the U. S. money table, and in radio. Ability to write a metric table.

NOTES ON EXPERIMENTS

Experiment 1 can be performed by taking two sheets of white paper. At the top of the one write "Visual memory"; at the top of the other, "Visual observation." On the visual memory sheet draw a line equal in length to what you think is the length of a postal card. Cover up this line, count five, and draw another line. Proceed in this way until 5 lines are drawn. On the visual observation card draw a line with the postal card in sight. Proceed as before until 5 lines are drawn. Measure

the length of all lines using a metric rule. Record your findings in the following way:

	Visual Memory	Visual Observation
Under-estimated	times	times
Over-estimated	times	times
Estimated correctly	times	times

Experiment 2 can be performed by using some object that has been accurately measured, a metric rule, and a hard sharp pencil. Record data similar to the following table:

Article Number.....		
Side AB	Side BC	Etc.
a.....cm.	a.....cm.	a.....cm.
b.....cm.	b.....cm.	b.....cm.
c.....cm.	c.....cm.	c.....cm.
d.....cm.	d.....cm.	d.....cm.
a + b + c + d 4 =Aver.	a + b + c + d 4 =Aver.	a + b + c + d 4 =Aver.
Perimeter of Average Lengths.....cm.		

Compare the amount of your error produced in the perimeter when single measurements were used with the amount produced when the average measurements were used. **Experiment 3** can be performed by using an English metric rule and measuring the length of a number of articles first in inches, then in centimeters. Verify by consulting a table in your textbook. **Experiment 3-a** can be performed by determining by examination the number of inches in a meter stick. By calculation determine the number of inches in 100 meters; the number of yards in 100 meters; in one kilometer. **Experiment 3-b** can be performed by carefully pouring water from a filled liter measure into a quart measure. Which holds more? After finding the exact differences in a textbook calculate the answer to the problem. **Experiment 4** can be performed by ascertaining in metric units on a platform balance the weight of "one pound weight" avoirdupois. **Experiment 5** can be performed by taking a stone or some other irregular shaped article and immersing in a graduated cylinder half filled with water. Note carefully the readings before the article was immersed and when it was immersed. This difference will represent the volume. **Experiment 5-a** can be performed by weighing a stone suspended on a balance. Weigh the same suspended stone when completely immersed in water. **Experiment 5-b** can be performed by finding the density of water as follows: Weigh a test tube. Pour 20 cc. of water into test tube and weigh again. Calculate weights per cc. of the water. To get density of wood, measure in centimeters the thru dimensions of a wood block. Find the volume in cc. Weigh block. Find weight per cc. To obtain the density of marble, suspend an irregular piece of marble in a noose and weigh it. To find the volume, carefully put it into a cylinder partly filled with water, and note the number of cc. of water it displaces.

DEVELOPMENT

Experiments 1 and 2: (1) Why are measuring devices such as rules, balances, etc. necessary? (2) How did you prove this? (3) Which of the following series is more quickly, more easily, and more accurately added? Why?

10+10+10+10+10+10+10+10+10+10
8+9+12+22+7+4+9+16+21+8

(4) Examine the English tables of linear measure, avoirdupois weight and liquid measure. Find out:

- a. How many different names must be remembered in each table.
- b. Whether the numerical differences between the parts of each table are irregular or uniform.
- c. How many different numbers must be remembered in each table.

(5) Examine the metric tables of linear measure, weight, and capacity. Find out:

- a. Whether there are any similarities among the prefixes to the unit names of the three tables.
- b. What the numerical differences are between the parts of each table.

(6) As a result of your findings in questions in the two preceding paragraphs, which system of tables, the metric or the English, is easier to remember and use? Why? (7) What are the numerical values of the following metric prefixes: milli, centi, deci, deca, hecto, kilo? (8) To what particular metric tables of measures do the unit names meter, gram, liter apply?

Experiments 3, 3-a, 3-b and 4: (1) In the following list of equivalents fill in the blanks:

Standard	Equivalent	Abbreviation
1 inch	centimeters	
1 meter	inches	
1 kilometer	miles	
1 liter	quarts	
1 kilogram	pounds	

(2) How many centimeters in a six-inch rule? (3) In a yard? (4) How many yards in five meters of cloth? (5) The distance between two cities is thirty kilometers. How many miles is this? (6) How many quart bottles could be filled from twenty liters of milk? (7) How many kilogram packages could be filled from eleven pounds of sugar? (8) List at least five uses of metric units in everyday life. (9) Name at least three uses of the metric units in your science laboratory work. (10) What nations of the world use the metric measurements in everyday life? Compare the United States money with English money by writing out each table. (11) Which is based on the metric system? Multiply \$5.93 by 7 and 5 pounds, 2s. 6d. by 7. (12) Which is the easier operation? (Time yourself in each). (13) In what different activities does the United States government use the metric system? (14) What are some of the common measurements of French and German fire-arms? (15) Weigh fifty grams of sand in a bag and poise in the palm of the hand. With this known weight of sand in one hand estimate the weight of five articles to be found within the room. Check by actual weighing. (16) It is sometimes said "a pint is a pound the world around." How many pounds does a pint of water weigh? Calculate as you did in Experiment 4. Is the above quotation correct? (17) Gasoline weighs about three-fourths as much as water. Calculate the weight in grams of a liter of gasoline after you have actually weighed a liter of water.

Experiments 5, 5-a and 5-b: (1) Make two pencil marks on a piece of paper at a distance which you believe to be twenty centimeters. Check with a rule. (2) Draw free-hand, five lines, each five centimeters long; five lines each two centimeters long; five lines each one centimeter long; and five lines each one-half centimeter long. Check with a rule. (3) Estimate the dimensions of ten articles that can be seen in the room and check. (4) Judge the capacity of test tubes, beakers, and flasks. Check by actual measurements. (5) A cylinder bucket is nine inches deep and has a diameter of nine inches. How many pounds of water will it contain when completely filled?

SUMMARY

We cannot depend on our unaided observations in measuring because we have a tendency to *over-estimate* or *under-estimate*. We can reduce our error in measuring by taking several measurements and calculating an *average*.

The metric system is easy to use because in any metric table the numerical parts are calculated according to the *decimal* system and because the same *prefixes* are used with each *unit* name.

The *gram* is the metric unit name in the weight table. The *meter* is the metric unit name in the length table. The *liter* is the metric unit name for volume.

Write completely one metric table.

The metric system is used by *scientists* throughout the world. In everyday life the metric system is used in the United States *money* table. It is also used in *radio* in referring to the wave length.

UNIT V

STARS AND THE SOLAR SYSTEM

GENERAL OBJECTIVES

A. The Idea of Universe

The concepts are two:

1. The realization of the vastness of the universe and the insignificance of the Earth and Man by comparison.
2. The majesty of order and the obedience to law as exemplified by the star groups and the solar system in their movements. We are not to study mathematical astronomy.

B. Star Study as Worthwhile Use of Leisure Time

The idea is to extend the work begun in the 7th Grade Course in recognizing the beauty of the heavens.

SPECIFIC OBJECTIVES	PROBLEMS FOR EXPERIMENT	DESIRABLE OUTCOMES
The Stars Stars and Star Distances	1. Why do some stars appear brighter and larger than other stars? (group experiment) 1a. How do astronomers express star distances? 2. What are some of the stars seen in winter?	Knowledge: 1. The stars are really great suns. 2. Stars are so enormously far away that distance traversed by light in one year (the light-year), is used to measure their position. Appreciation of the vastness of the universe.
The Solar Family The Members of the Solar Family	3. How far away are the planets? (class experiment)	Knowledge: The solar system consists of the sun, the planets and their moons, asteroids, comets, and meteors. The ability to distinguish planets from stars.
How the Solar System Moves	4. What makes the solar system move? (group experiment) 4a. What holds the solar system together? (teacher experiment to simulate gravitation)	Realization that: 1. The sun is the center of the solar system and the source of all energy on the earth. 2. The motions of the sun, earth, and moon determine our time divisions and, together with the tilt of the earth's axis, our seasons.

NOTES ON EXPERIMENTS

Experiment 1 can be performed by using the following apparatus and following these directions: 1—Apparatus: Two candles; two pieces of waxed paper or smoked glass four inches square. 2—Directions and observations: (a) Arrange lighted candles about ten feet apart. Are the candle flames equal in size? (b) Stand about two feet away from one candle so that the second is about twelve feet away. (Smoked side toward you.) Mark on the glass where the top and bottom of flame appear. Look at the farther candle and mark the apparent size of the flame. Compare the sizes of your markings. Which flame seems to be larger? (c) On a clear night stand on the street corner where you can see two street lamps of equal size. One lamp should be in the middle and the other at the end of the block. Which lamp apparently gives you more light? Which lamp seems larger? (d) Look up at the stars. Pick out some very bright ones and some that are very dim. Are the bright stars necessarily larger because they appear so to you? Are they necessarily nearer? **Experiment 1-a** can be performed by switching on and off the electric lights in the room. Does any time seem to elapse between the "click" of the switch and the time the light appears? Look out the window. Imagine a

board extending out toward the sky for the enormous distance of 186,000 miles. Imagine a boy at the other end with a powerful search light. If at a given signal the boy should turn on the light, one second later the light would reach you. Light travels 186,000 miles per second. Write out a formula for finding the distance light travels in one year. This distance is called the "light year." **Experiment 2** can be performed by using the following apparatus and following these directions: 1—Apparatus: Sheet of unruled paper in your notebook; pencil. 2—Directions and observations: (a) Recall 7th Grade Course, "What the Sky Gives Us," Experiments 1 and 2. Be sure that you can find the North Star and the constellations of the Great Dipper, Cassiopeia, and Orion before proceeding with this lesson. Select a clear evening for your observations. Choose a locality as free from street lamps and electric lights as possible. Face towards the south. Find Orion. Notice the four bright stars which form the corners of an oblong in the constellation of Orion. The one forming the southeast corner of the oblong is called Betelgeuse. Imagine a line drawn diagonally from Betelgeuse to the star forming the northwest corner of the oblong. This star is called Rigel. Betelgeuse is a giant among stars. Its diameter is 215,000,000 miles. Our sun and the entire orbits of Mercury, Venus, and the earth would

easily fit in its flaming mass. It is 160 light years away. Follow the three stars in the belt of Orion toward the southeast. There you will find a very bright star called Sirius, the Great Dog Star. Sirius is the brightest star in the heavens. It was worshipped by the Egyptians when the Pyramids were built and was spoken of by Homer, the Greek poet. It is forty times as big as our sun. It is only twenty-two light years away. Imagine a line drawn from Rigel to Betelgeuse. Starting from Sirius imagine another line drawn southeastward and parallel to the first line and a little longer. It passes near Procyon, another bright star. Extend the line of the stars in Orion's belt in the direction opposite from Sirius until it meets a group of stars arranged like the letter "V", called the Hyades. The bright star at the end of one side of the "V" is Aldebaran. Aldebaran is a red star which forms the eye of Taurus, the Bull. Extend the line from Orion's belt to Aldebaran nearly as far again and it will pass near a cluster of stars, six of which are visible to the naked eye. This star group is the Pleiades, called the Seven Sisters by the Greeks. By means of photography more than 3,000 stars have been found in this group. The Pleiades are about 600 light years away. Imagine a line drawn from Sirius to the first star in the belt of Orion. From this star imagine a line drawn at right angles to the first line and extending southeastward. It will end near two bright stars close together. These stars are known as Castor

Experiment 3 can be performed by using the following apparatus and following these directions: 1—Apparatus: Half bucket of clay, water; English-metric rule; meter stick. 2—Directions and observations: Study the following table:

Planet	Diameter	Distance from the Sun
Mecury	2,765 miles	36,000,000 miles
Venus	7,726 "	67,200,000 "
Earth	7,913 "	92,900,000 "
Mars	4,312 "	141,500,000 "
Jupiter	84,570 "	483,300,000 "
Saturn	69,780 "	886,000,000 "
Uranus	31,900 "	1,781,900,000 "
Neptune	34,900 "	3,665,600,000 "
Pluto	4,500 "	3,700,000,000 "
The Sun	866,540 "	

(a) Letting one millimeter represent 1,000 miles, draw lines representing the diameter of the sun and of each planet. (b) Letting one millimeter represent 100,000 miles, calculate the distances of the planets from the sun. Convert this millimeter distance (approximately) into feet by dividing by 305. Using the clay and water make up nine balls of the proper sizes to represent the sun and the planets. Use the millimeter scale of the diameters to help you. (c) In an appropriate spot near the school put the ball representing the sun. Place the balls representing the different planets at the proper

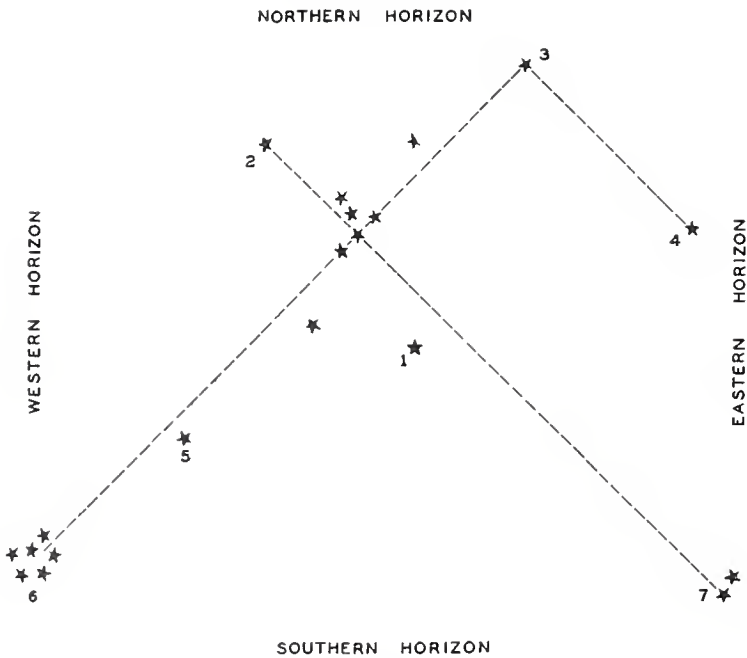


Figure 44

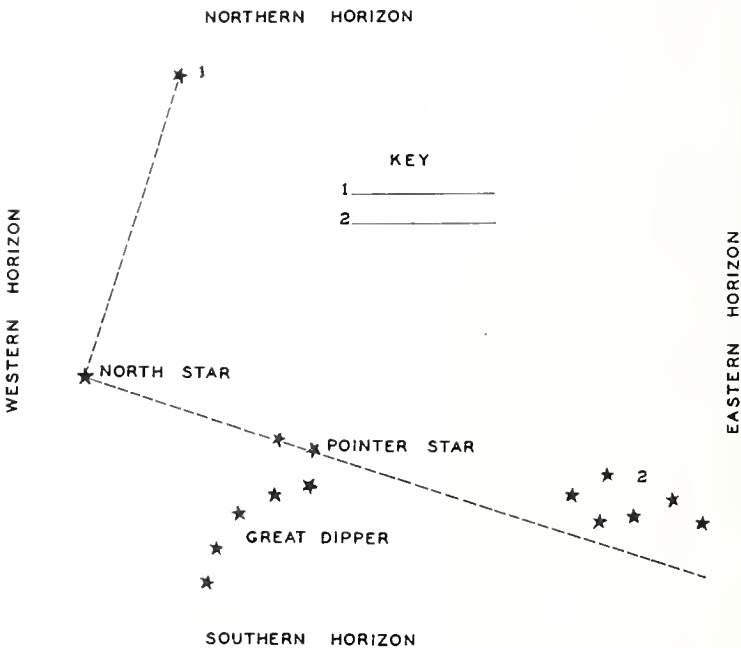


Figure 45

and Pollux, sometimes called the Heavenly Twins. (b) For your "Observations" copy figure 44 in your notebook. Fill out the key with the names of the stars you have found. Face towards the north. Find the Great Dipper. Imagine a line drawn from the Pointers of the Great Dipper to the North Star. At this point imagine a line drawn at right angles to the first line in a northeasterly direction and about one and a half times as long. It ends near a bright star called Capella. Capella gives off about 200 times as much light as our sun. At about 8 p. m. in late January this star will be exactly overhead. Capella is in the constellation called Auriga, the Charioteer. January classes may include the following: Extend the imaginary line from the North Star to the Pointers eastward. Just northeast of this line are six stars forming the constellation of the Sickle. You will easily recognize the handle and curved blade. The bright star at the end of the handle is Regulus. (c) For your "Observations" copy figure 45 in your notebook. Fill out the key with the names of the stars you have found.

distances from the sun. Experiment 4 can be performed by noting the pull exerted by a two-inch rubber ball on a string one yard in length when whirled in a vertical plane. Make sketches showing the path the ball takes when it is suddenly let go while being whirled. Look up "centrifugal," "force" and "inertia" before making conclusions. Experiment 4-a can be performed by placing a large pan of water on a table and let it stand until the surface of the water is perfectly quiet. Place 2 disks cut from a large cork in the water about 1/2 inch apart. Note what happens. Remove one of the pieces of cork and place a smaller cork about 1/2 inch away from the remaining piece. Note result. Place a still smaller piece of cork halfway between the two pieces in the pan. Note carefully what happens. Place all the pieces of cork in the water. Scatter cork filings over the water. Stir vigorously and let them stand undisturbed for about an hour. In what position do the pieces of cork finally arrange themselves?

DEVELOPMENT

Experiments 1 and 1-a: (1) Why cannot we use the naked eye to judge the sizes or distances of stars? (2) About how many stars can we see with the naked eye? (3) What determines the magnitude of a star? (4) How far away is the nearest star? (5) Suppose the light of the star Betelgeuse were suddenly blotted out tonight, how long would it be before observers on the earth would become aware of it? (6) What is the Milky Way? (7) Why does it have this appearance to the naked eye?

Experiment 2: (1) Why does the sky appear to be a great hollow sphere? (2) What is the horizon? (3) What is the zenith? (4) If the stars are always shining why cannot we see them during the day and every night? (5) In which star are we most interested? Why? Recall 7th Grade Course, "What the Sky Gives Us," Experiments 1 and 2, to answer the following: (6) What are the stars? (7) Why is the North Star so important to us? (8) What is a constellation? (9) What constellations can you name and identify? (10) Which are scientists, astronomers or astrologers? (11) What are some of the superstitions connected with ancient star study? (12) What star stories do you know? (13) What is a meteor? (14) A meteorite? (15) A comet? (16) What great comet discovery did most to remove superstition from astronomy?

Experiment 3: (1) What is meant by the word planet? (2) Why were certain of the heavenly bodies called planets by the ancients? (3) What shape are the planets? (4) What facts help us to distinguish planets from stars? (5) What is meant by Morning Star? (6) Evening Star? (7) What does solar mean? (8) What makes up the solar system? (9) Which is the smallest member? (10) Which is the largest? (11) Which one is nearest to our sun? (12) Which member is farthest away from our sun? (13) Which ones are visible to the naked eye? (14) The discovery of which planet may be called the triumph of the telescope? (15) Which the triumph of mathematics? (16) Which the triumph of photography? (17) Which planet is inhabited? (18) Which ones have possibilities of habitation? (19) Which member is noted for its rings? (20) When and where was Pluto discovered?

Experiments 4 and 4-a: (1) What motions do the planets have with reference to the sun? (2) What other motions do the planets have? (3) Does the sun itself move? Recall 7th Grade Course, "What the Sky Gives Us," experiment 3, to answer the following: (4) What causes day and night? (5) What causes our year? Days and nights are of unequal length throughout the year. (6) How can this be explained? (7) Why do the polar regions have approximately six months of daylight and six months of dark

ness? (8) Will all the planets have days and years equal in length? Explain. Recall 7th Grade Course, "What the Sky Gives Us," experiments 4 and 4-a to answer the following: (9) Is the moon a planet? Why? (10) Why does it have different shapes or phases? (11) What is an eclipse? (12) What causes an eclipse of the sun? (13) Does the sun ever come between the earth and the moon? Why? (14) Is it true that the sun is the source of all energy? (15) What makes it possible for the sun to do work? (16) How does the sun do work on the earth and moon? (17) Imagine this world without sunlight. Tell what would or would not exist upon it and what would or would not be done upon it. (18) Does the moon do any work upon the earth? (19) How can the change of seasons in the temperate zones be explained? (20) If the earth's axis were made vertical to its path what effect would this change have on our seasons?

SUMMARY

The *sky* is a make-believe sphere; the *earth* seems to meet it at the *horizon*. The stars in the sky are really great *suns*. To us they seem *near* together and very *small* because they are so far away. Stars are so enormously far away that we must use the speed of *light* to measure their distances. The *light* year, the yard stick of the heavens, is the distance traveled by *light* in one *year*.

The solar system consists of the *sun*, the 9 *planets*, *moons*, *asteroids*, *comets*, and *meteors*.

Planets are *spherical* shaped bodies which *rotate* on their axes and *revolve* about the sun.

Planets may be distinguished from stars because *stars* twinkle and *planets* do not. Stars do not seem to *move* with relation to each other, while planets *move* across the *stars*.

The sun is the *center* of our solar system. It is the source of all *energy*. No *work* is done on our earth without the direct or indirect help of the sun. The tremendous attractive power of the sun operating through *gravitation* and *centrifugal force* keeps the planets revolving in their orbits.

Our earth's *shape*, the tilt of its axis, and its *revolution* about the sun, cause our *seasons* and give us our year. Its rotation on its *axis* gives us our *day*, hours, minutes, and seconds. The *moon's* revolution around the earth gives us our month and week.

Review 7th Grade Course, summaries to "What the Sky Gives Us," Unit V.

UNIT VI

MAKING USE OF HEAT

GENERAL OBJECTIVES

The realization that heat is linked with Movement.

Emphasis is placed upon the use of this fact in the environment.

For example, the motion resulting in conduction and convection as applied to ventilation and heating in our homes.

The use of evaporation and condensation in industrial processes and everyday life.

SPECIFIC OBJECTIVES	PROBLEMS FOR EXPERIMENT	DESIRABLE OUTCOME
Heat and Motion		
Conduction in Solids	1. Why do we have wooden handles on hot irons? (group experiment) 1a. Why are the walls of a fireless cooker and the walls of a refrigerator packed with felt or asbestos? (class experiment) 1b. How can I test the efficiency of our refrigerator?	Knowledge of the concepts: Conduction, convection, and radiation. Appreciation of the value of conductors and non-conductors of heat.
Convection in Liquids and Gases	2. How is heat able to reach the upper floors of a building from a hot water or hot air heating system? 2a. Why do we lower an upper window sash and raise a lower one in order to ventilate a room? (class experiment)	
Radiation	3. How does the heat of the sun reach us? 3a. How can heat be "trapped?" (class experiment)	
Some Uses of Heat in Industry and in the Home		
Evaporation and Condensation (Distillation)	4. Does distillation always purify water? 4a. How can we make an illuminating gas? 5. Which is more efficient in heating our homes, steam or hot water? (class experiment) 5a. How can we construct a model steam heating plant? (teacher experiment)	Knowledge of the relation of evaporation and condensation to distillation and to heating systems.

NOTES ON EXPERIMENTS

Experiment 1 can be performed by attaching a number of rods on a wooden block as shown in figure 46. A drop of candle grease is placed on each rod at A, B, C and D. A flame is supplied at E and the time noted, when the wax drops from the end of the rod. This may be entered in the following chart:

<i>Substance Tested</i>	<i>Rate of Heat Conduction</i>
iron	 minutes
aluminum	 minutes
copper	 minutes
glass	 minutes

Experiment 1-a can be performed by obtaining two wide mouth bottles of equal size and fit each with a one hole stopper. Wrap one bottle tightly with wool, felt or cotton batting. Fill the bottles with equal amounts of hot water of about 180° F. Stopper each bottle, pass-

ing a thermometer down each one into the water. Read the thermometers every five minutes for twenty minutes and record. Repeat the operation using ice water instead of hot water. **Experiment 1-b** can be performed by placing a thermometer in the food compartment of the refrigerator nearest the ice. Close the door for ten minutes, then open it quickly and read the temperature. Wrap the ice in a blanket or in several thicknesses of newspaper. Proceed as before. What must the ice be allowed to do if the refrigerator temperature is to be maintained at the proper point? **Experiment 2** can be performed by placing over a Bunsen burner a Florence flask filled with water mixed with a teaspoonful of sawdust. Note the movement of the sawdust particles as the water becomes heated. **Experiment 2-a** can be performed by arranging 2 Argand chimneys and candle in a prepared chalk box. Hold a few smoking punk sticks, first at chimney A and then at B and note the direction of the smoke. Feel the temperature over A and B. **Experiment 3** can be performed by holding the hand beneath a window pane through which the sun is shining. Place the hand immediately on the window pane. Repeat using a reading glass. Hold the reading glass focused on the head of a match for a few seconds. In all cases note that the hand seems to have been warmed by the passage of the heat rays from the sun, while the glass does not seem to have been affected. **Experiment**

3-a can be performed by securing two baking powder cans. Polish the outside of one can and smoke the outside of the other one by rotating it in a candle flame. Fill the cans with boiling water and place them in the shade, out of a draft. At the end of 10 minutes, and again 10 minutes later, take the temperature and record.

Experiment 4 can be performed by using the following apparatus and following these directions: 1—Apparatus: Two iron supports; two cast iron rings; burette clamp; 500 cc.; Florence flask with two-hole stopper to fit; thistle tube; delivery tube; two test tubes; beaker; water; ammonium hydroxide; phenolphthalein; mud; Bunsen burner; wire gauze; pipette. 2—Directions and observations: (a) Take one test tube and fill it one-third full of water. Add a drop of phenolphthalein and note result. Next add a drop of ammonia water (ammonium hydroxide) and note result. This result is a test for the presence of ammonium hydroxide. Set this test aside. Assemble the other parts of the apparatus as in figure 47. Partly fill the Florence flask with water and add some mud. The water in the beaker containing the test tube must be cold. (b) Place a lighted Bunsen burner under the flask and note results in the test tube. (c) Now add a drop of phenolphthalein to the contents of the test tube and note result. (d) Next add a few drops of ammonium hydroxide to the Florence Flask by way of the thistle tube. Note the results.

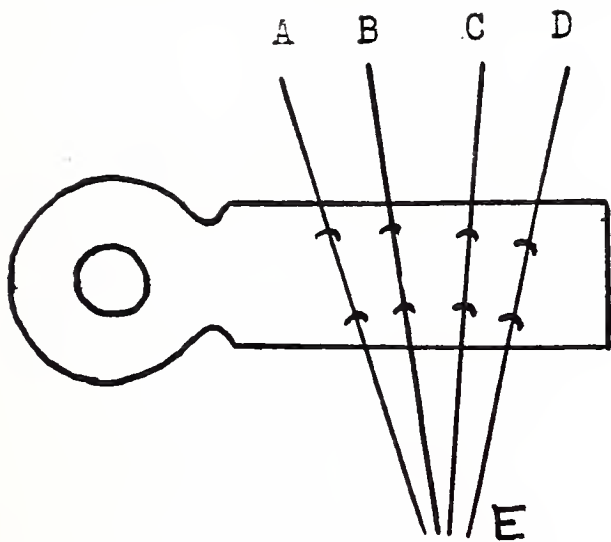


Figure 46

Experiment 4-a can be performed by placing a few chips of wood into a test tube and heat gently and then more strongly. As soon as the smoke becomes dense apply a lighted match to the open end of the tube. Continue to heat until no more smoke comes off. Examine the material left in the test tube. **Experiment 5** can be performed by using the following apparatus and following these directions: 1—Apparatus: Large beaker; steam trap; glass tubing; rubber tubing; Florence flask; thermometer; iron support with cast iron ring; wire gauze; burette clamp; Bunsen burner; water; balance with weights. 2—Directions and observations: Construct a steam trap. (a) Weigh the beaker when it is half full of cold water. Record. (b) Record the temperature of the water in the beaker. Boil some water in the flask. Assemble the apparatus as shown in figure 48. (c) Connect the steam trap and when the water is boiling put the free end of the trap into the beaker of cold water. Continue boiling for about five minutes. Remove the trap. Stir well and record temperature. (d) Weigh and calculate the amount of water which came from the condensed steam. Note: Do not remove the flame before removing the trap from the beaker. Weigh out the same quantity of cold water used in "a" and at the same temperature. Pour into it a quantity of boiling water equal in weight to that of the steam added in "b." (e) Mix thoroughly and take

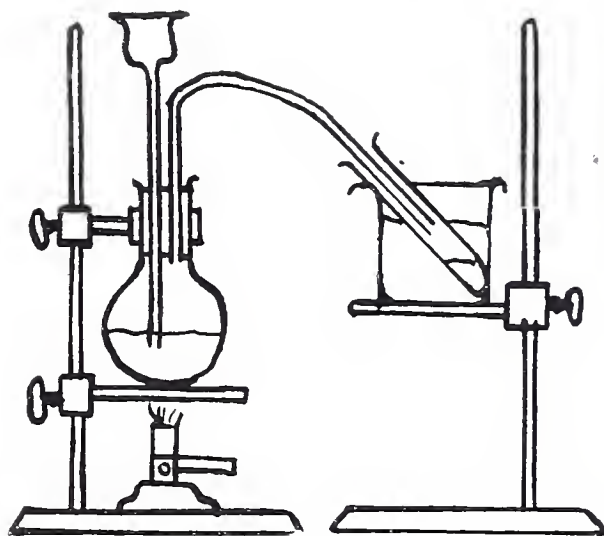


Figure 47

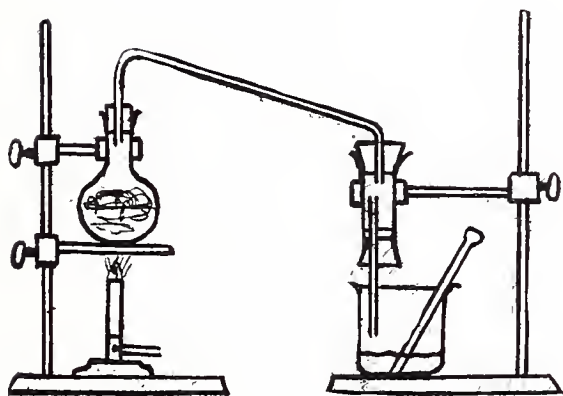


Figure 48

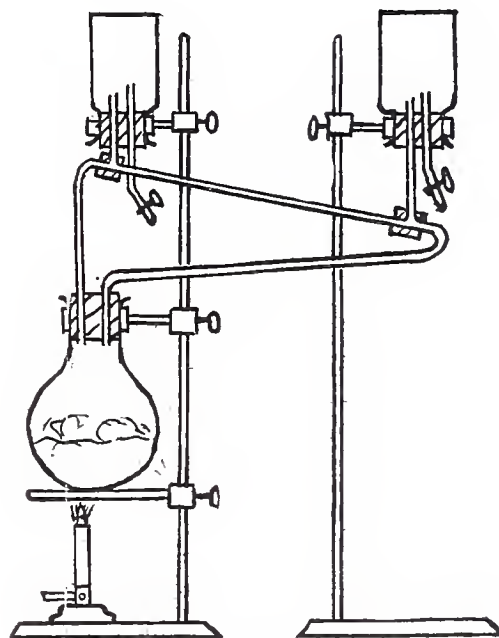


Figure 49

the temperature. (f) For your observations, fill in a chart like the following:

With Steam	Weight of beaker, water, and condensed steam	gm.
	Weight of beaker and cold water	gm.
	Weight of steam added	gm.
	Rise in temperature	°F
With Hot Water	Weight of hot water added	gm.
	Rise in temperature	°F

Experiment 5-a can be performed by using the following apparatus and following these directions: 1—Apparatus: Iron support; cast iron ring; wire gauze; three burette clamps; #5 one-hole stopper; two eight ounce wide mouth bottles with two-hole stoppers to fit; 500 cc. Florence flask with two-hole stopper to fit; two pinchcocks (Mohr); rubber tubing; glass tubing; Bunsen burner; water. 2—Directions and observations: Assemble the apparatus as shown in figure 49. (Note: The T-joints are made by boring into the sides of the one-hole stoppers.) (a) Place a small quantity of water in the Florence flask and heat with the Bunsen flame. (Use great care.) Feel each of the bottles from time to time. Result? (b) Open each pinchcock for a few seconds. Result? Note: Two “T” shape tubes may be used, with four short pieces of rubber tubing instead of the one-hole stoppers.

DEVELOPMENT

Experiments 1, 1-a and 1-b: (1) When a silver spoon is left standing in a cup of hot tea why does the spoon handle become so very hot? (2) Will good or poor heat conductors cool quicker when withdrawn from the source of heat? (3) Why does a stone step feel cooler than a wooden one? (4) After consulting a science text, explain the theory of the way heat travels through heat conductors. (5) Why do birds and other animals fluff out their feathers and fur in summer, and in winter? (6) Why do we wear cotton and linen clothing in summer and woolen clothing in winter? (7) Is it true that woolen clothing keeps out cold in winter? (8) What is a fireless cooker? (9) How is a refrigerator constructed? (10) Can you make one? (11) Why does a rug feel warmer to our bare feet than a wood or tile floor? (12) Why does a newspaper protect plants from frost? (13) Why is a fur coat warmer if the fur is on the inside?

Experiments 2 and 2-a: (1) Why is it that south winds are able to bring heat to Philadelphia? (2) Why is the water of the Gulf Stream quite warm as far north as the British Isles? (3) How does an electric coffee percolator illustrate convection? (4) How does the transfer of heat by convection differ from transfer of heat by conduction? (5) How does the radiator in an automobile operate so as to cool the engine? (6) Review 7th Grade Course, “Making Use of Water,” Experiment 1, and explain how a hot water heating system operates.

Experiments 3 and 3-a: Sun rays must travel 92,000,000 miles to reach the earth. Practically all of this distance is an empty space (vacuum). (1) Why does this not interfere with the effectiveness of the heat rays? (2) How does the sun warm a “hot house”? (Review 7th Grade Course, “What the Sky Gives Us,” Experiment 6). (3) What is the cause of “sunburn”? (4) Why should the surface of a tea kettle be brightly polished and the bottom blackened? (5) Why does dirty snow melt more quickly than clean snow? (6) Why is it that people in the tropics prefer to wear white clothing?

Experiments 4 and 4-a: (1) Why does shellac dry so quickly? (2) What is the cause of rain? (3) Make a diagram to illustrate the scientific processes involved in the Water Cycle of Nature. Review 7th Grade Course, “Making Use of Water”, Experiment 2. (4) Make a diagram to explain how evaporation is used in an ice making machine. (5) What is a distillate? (6) What commercial products used in the home or in industry can you name that are distillates? (7) What is meant by residue in the process of distillation? (8) What products can you name that are produced from residues? (9) What is “fractional distillation”? (10) By what process is coal gas made? (11) What are some by-products obtained by fractional distillation in the coal gas industry? (12) In wood distillation?

Experiments 5 and 5-a: (1) Can you explain how central steam heating plants can compute bills for the steam used by examining the amount of water in the steam trap of each home? (2) Are there any examples of “central heating plants” for private homes in your city? (3) What are the charges to individuals? (4) What uses of steam heat can be made other than for heating a room? (5) What is a calorie?

SUMMARY

Conduction of heat in *solids* is the *transfer* of heat by *particles* that are in *contact* with each other.

A heat conductor is a material through which heat *can* pass easily.

A heat non-conductor is a material through which heat *cannot* pass.

Convection of heat in *liquids* or *gases* is the *transfer* of heat by *particles* which *move* from the source of *heat* to some other *place*.

Distillation is the process of *separating* one substance from another by *evaporating* one of the substances and then *condensing* its *vapor*.

A distillate is a substance which has been *evaporated* and then *condensed* in the process of *distillation*.

Review 7th Grade Course—“How Heat changes Substances,” Unit IV, Experiments 5 and 6.

UNIT VII

THE RELATION OF PLANTS AND ANIMALS TO MAN

GENERAL OBJECTIVES

The important objective is to realize that by the use of science, man can control plant and animal life to his own uses.

1. The improvement of food and clothing materials

Through the knowledge of soil fertility, plant yields have been increased.

Through the scientific application of the Mendelian principle improvements of plant and animal forms have been achieved. No detailed nor mathematical elaboration of the Mendelian laws is intended.

2. The importance of micro-organisms to man's progress

The concept to be developed here is the role played by micro-organisms in aiding and retarding man's progress. We are not studying the science of bacteriology nor the various structural type of bacteria.

SPECIFIC OBJECTIVES	PROBLEMS FOR EXPERIMENT	DESIRABLE OUTCOMES
Man's Quest for Food		
Plant Products	1. What food substances are in the things we eat? (group experiment)	Knowledge: The 7 food substances required by the human body, and a simple method of detecting the presence of each.
Animal Products	1a. What food substances are found in some animal products? (group experiment)	
How Man Solves His Food Problem	2. What are the necessary contents of fertile soil? (class experiment)	The realization that agriculture is man's most important industry.
Soil Cultivation		
Gregor Mendel's Discovery and What Came Of It	*"Gregor Mendel—His Experiments and Laws He Derived From Them" *"Luther Burbank—His Application of Mendel's Law"	Knowledge: 1. The use of fertilizers, rotation of crops, and of irrigation in the production of food plants. The application of Mendel's laws in the improvement of plants and animals and their products.
Plant Foes and Friends		
Work of Bacteria	3. Part 1: How can we prepare food to grow bacteria? (class experiment) Part 2: How can we sterilize this food material? (class experiment) 4. Are clean hands really clean? (class experiment) 4a. Why is coughing or sneezing dangerous to other people? (class experiment) 4b. Why is milk Pasteurized and how should it be done? (class experiment)	Knowledge: 1. Micro-organisms are the chief causes of the destruction of food. 2. Foods can be protected by refrigeration, sterilization, and the use of harmless preservatives. 3. Micro-organisms are the chief cause of disease. 4. There are effective guards against disease infection. 5. Some micro-organisms are helpful.
Work of Molds	5. When will bread get moldy? (class experiment or home experiment)	
Work of Yeasts	6. What happens when yeast gets into a sweet liquid, such as fruit juice? (class experiment) 6a. What causes dough to "rise" when bread is baked? (group experiment)	
Work of Insects, Birds and Toads	Review 7th Grade Course, "Exploring Nature," Experiment 1, and 8th Grade Course, "Plant Friends and Plant Enemies," Experiments 3a, 4, 5, 5a	

* Reports.

Man's Clothing and Shelter Problem

Plant and Animal Fibers and Their Uses

7. Parts 1 and 2: How do clothing fabrics keep us warm? (group experiment)

7a. How can we test wool, silk, linen, and cotton?

**Vegetable Fibers

**Animal Fibers

Realization that:

1. Clothing protects by preventing or allowing the escape of heat from the body.
2. Fabrics holding the largest quantity of air between the fibers are the warmest because they prevent the escape of heat.
3. Only fibers having a curl or twist can be spun into yarn for weaving cloth.

Our Dependence on Trees

Review 7th Grade Course, "Flowers and Plants" Experiment 6

NOTES ON EXPERIMENTS

Experiment 1 can be performed by using the following apparatus and following these directions: 1—Apparatus: Prune or other dried fruit cut into four small pieces; four pieces of cooked potato each the size of a small pea; shelled peanut broken into four small pieces; one-half teaspoonful of corn meal; 25 cc. of concentrated nitric acid; 25 cc. of Fehling's solution; 5 cc. of dilute iodine tincture; five pieces of unglazed paper each folded in half; four six-inch test tubes; Bunsen burner; test tube support; pipette; graduated cylinder. 2—Directions and observations: (a) In separate test tubes place pieces of dried fruit, potatoes, peanuts, corn meal. To each add 5 cc. of concentrated nitric acid and heat carefully over the Bunsen burner. Note which of the substances, if any, assume a yellow color. This is a test for proteins. (b) Clean out the test tubes and repeat the experiment as in "a" using 5 cc. of Fehling's solution instead of the nitric acid. Set aside and later note whether any of the substances assume a copper like color. This is a test for sugar. (c) Moisten one of each of the remaining food samples with water and add one drop of dilute iodine tincture. Note whether any of the substances assume a bluish or purplish color. This is a test for starch. (d) Place the remaining sample of each food between the folds of the papers and press the papers tightly between the fingers. Hold each paper up to the light. Note whether any of the substances give the paper a translucent spot. This is a test to detect the presence of fat or oil. **Experiment 1-a** can be performed by applying the same tests as in Experiment 1 to the white and yolk of a hard boiled egg; to bacon or other animal products. **Experiment 2** can be performed by using the following apparatus and following these directions: 1—Apparatus: Three six-inch flower pots; clay; sand; garden soil; one quarter teaspoonful of ammonium nitrate; one-eighth teaspoonful of potassium chloride; one tablespoonful of powdered rock phosphate or bone meal; 48 oat seeds. 2—Directions and observations: (a) Into each of the flower pots put a layer of clay one inch deep. (b) Fill pot #1 with good garden soil; pot #2 with cleanly washed sand; pot #3 with the following mixture: cleanly washed sand mixed with ammonium nitrate, potassium chloride, and phosphate or bone meal. (c) Plant sixteen of the soaked seeds in each pot, about three-fourths of an inch below the surface. Record the date of planting. Set the pots in a warm room where they will get diffused light, but not direct sunlight. Keep the soil moist, but not wet. (d) When the seeds have sprouted set the young plants in sunlight, watching their growth from day to day for several weeks. **Experiment 3, Part I**, can be performed by using the following apparatus and following these directions: 1—Apparatus: Two medium sized white potatoes; one-half ounce gelatine; three eight-inch test tubes; three plugs of sterilized absorbent cotton for the test tubes; fine wire sieve or strainer; two quart cooking pan filled with water; Bunsen burner; paring knife; cast iron tripod. 2—Directions and observations: Pare

and slice the potatoes. Place in the cooking pan and cover with the cold water. Bring to a boil and continue boiling for ten minutes. Strain off one pint of the liquid. Into this stir the gelatine (broken into small pieces). Set aside for ten minutes, then heat again until the gelatine is dissolved. Strain the liquid and pour into the test tubes, filling each three-fourths full. Plug each tube with a wad of absorbent cotton. The gelatine mixture is now ready to be sterilized. **Experiment 3, Part II**, can be performed by using the following apparatus and following these directions: 1—Apparatus: Three eight-inch test tubes of gelatine mixture each plugged with a cotton wad; six Petri dishes with covers; pair of long handled tongs; two quart cooking pan; small towel or clean dish cloth; Bunsen burner; cast iron tripod. 2—Directions and observations: Place the cooking pan on the tripod. Put the towel in the bottom. Pour in water until it is about three inches deep. Remove the covers of the Petri dishes and carefully place them and the dishes in the water. Put the test tubes in water, propping them up if necessary so that the cotton plugs will not become wet. Carefully place the tongs in the water so that the handle ends will not fall into the pan. Light the Bunsen burner under the tripod and boil the water slowly for half an hour. The food material, Petri dishes, and tongs are now sterilized and are ready for use in Experiments 4, 4-a and 4-b. **Experiment 4** can be performed by placing in each of two Petri dishes thoroughly sterilized one eight-inch test tube of sterilized gelatine mixture. Cover immediately. All handling of dishes and covers must be done with the tongs and not with the hands. After the gelatine has hardened, raise the cover of one dish and gently touch the surface of the nutrient with the tips of the fingers. Lower the cover. Mark the dish "Dirty hands." Using plenty of soap and water, wash the hands thoroughly being sure to wash around the finger nails. Raise the cover of the other Petri dish and touch its surface with the clean finger tips. Lower the cover. Mark this dish "Clean hands." Set these dishes in a warm dark place and examine at the end of four days. Note the difference. **Experiment 4-a** can be performed by removing the cover from a sterilized Petri dish of gelatine (proceed as in Experiment 4), and holding the open dish about two feet away from the face, cough vigorously two or three times over it. Cover immediately. Set aside in a warm, dark place. In four days examine for bacteria colonies. **Experiment 4-b** can be performed by using the following apparatus: Four beakers; quantity of milk; thermometer; Bunsen burner; cast iron tripod; three prepared Petri dishes containing gelatine nutrient; pipette; six paper labels; water bath*; wire gauze. Proceed as follows: Put equal parts of milk in three separate dishes. Label them 1, 2, and 3. Leave 1 exposed to the air for forty-eight hours. Heat milk in 2 for twenty minutes over a water bath, bringing it to a temperature of 145° F. (no higher). Set this pasteurized sample aside for forty-eight hours exposed to the air. Boil milk in 3 for ten minutes. Set aside as before for forty-eight hours. (a) Taste milk

* To make water bath, place a test tube containing the raw milk in the beakers nearly filled with water. Heat as directed.

** Museum Lessons.

in each beaker after cooling. Note effect of boiling on appearance of milk. (b) Examine all samples after forty-eight hours. Taste each and note any change. Using pipette place five drops of milk from beakers 1, 2 and 3 in prepared Petri dish. (c) Store samples for forty-eight hours. Do all contain bacteria? Which has most? Which has least? **Experiment 5** can be performed by using the following apparatus and following these directions: 1—Apparatus: Eight jelly glasses; covers to fit four of the glasses; four pieces of blotting paper cut to fit the glasses; two thick slices of bread dried out thoroughly; gummed label for each glass; compound microscope; two micro slides; two cover glasses. 2—Directions and observations: Paste a label on each glass and number the glasses from 1 to 8. Wet the blotting paper with warm water and place a piece in each of the glasses 1 to 4. Cut the bread into eight pieces, each about the diameter of a half dollar. Place a piece of the bread in each of the eight glasses and set away in a dark place or sunny spot as follows:

1. damp bread	uncovered	dark
2. damp bread	covered	dark
3. damp bread	uncovered	sunny
4. damp bread	covered	sunny
5. dry bread	uncovered	dark
6. dry bread	covered	dark
7. dry bread	uncovered	sunny
8. dry bread	covered	sunny

In glasses 1 to 4 put ten drops of water on each of the pieces of blotter every second day. (a) Examine the glasses every two days for a week. Record your observations in a table like the following:

Uncovered Glasses				Covered Glasses			
in the light		in the dark		in the light		in the dark	
damp	dry	damp	dry	damp	dry	damp	dry

If mold, bearing black spores, is found, examine as follows: (This portion of the experiment is to be performed by the teacher.) Take the bread out of the glass and with forceps remove a few of the complete mold plants and mount them on a slide in a drop of water under a cover glass. (b) Examine under low power. Mount another plant in the same way and examine the spores under the high power. Note the spore cases, spores (which correspond to seeds of green plants), the filaments, which support the spore cases, and the mycelia, which serve as roots. **Experiment 6** can be performed by using the following apparatus and following these directions: 1—Apparatus: Flask; one-hole stopper; delivery tube; test tube containing lime-water; bit of yeast cake; three tablespoonfuls of molasses; warm water. 2—Directions and observations: (a) Dissolve the piece of yeast cake in a cupful of lukewarm water. Stir the molasses into this solution and pour the mixture into the flask, adding enough warm water to fill the flask about two-thirds full. Note the odor of the mixture. (b) After inserting the delivery tube through the stopper, place it in the flask. Place the other end of the delivery tube into the lime-water and set the apparatus aside until next day. Note what has happened in the flask and in the lime-water. (c) Smell the liquid in the flask. Note the odor of alcohol which is now present in the liquid. Compare this odor with the original odor of the molasses mixture. The process by which the alcohol was produced is called fermentation. **Experiment 6-a** can be performed by mixing dry flour and a little sugar together. Add water and form a dough. Place one-half of the dough in a beaker. To the other add

yeast and place in another beaker. Place both beakers in a warm room for twenty-four hours. Result? Cut a portion of dough from each sample. In which do you find bubbles? **Experiment 7, Part I**, can be performed by taking four tin cans of equal size, and wrap about one a piece of woolen cloth, about another silk, about another cotton and about the fourth one linen. Fill each of the cans with sufficient water at 140° to 150° F. and record the temperatures of each every thirty minutes. **Part II** of experiment 7 can be performed by taking samples of woolen, cotton, silk and linen cloth and noting which absorbs water easily and which does not; also, which fabric feels "wettest." Also, after having laid aside for ten minutes note which is the driest. Now take a thread obtained from each of the fabrics at the beginning and place on separate micro slides with a finger on one end of each. Use a needle to "tease" out the other end into the separate fibers which compose it. Place another slide over the threads so that the fibers are spread out between the pieces of glass, and place under the clips on the stage of a microscope. Examine these fibers under low power, noting which have the most kinks or twists, scales or barbs. Record your observations in a chart like this:

Characteristics	Cotton	Linen	Wool	Silk
Absorbs water quickly				
Absorbs water slowly				
Fibers straight				
Fibers kinky				
Fibers scaly				
Woven fibers would lie close together				
Woven fibers would not lie close together				

Experiment 7-a can be performed by pulling out several threads from samples of wool, silk, cotton and linen. Make the following tests on threads from the four samples:

Tests	REACTION			
	Wool	Silk	Linen	Cotton
Burning (Set fire to threads in an evaporating dish.)	Odor of Burnt Feathers			
Lye Test (1 inch of potassium hydroxide dissolved in 100 cc. boiling water.)	Dissolves Wool	Dissolves Silk		
Acid Test (100 cc. of concentrated hydrochloric acid heated almost to boiling.)		Dissolves Silk		
Olive Oil Test (Place a drop of olive oil on each sample of cloth.)			Produces Translucent Spot	

NO REACTION

DEVELOPMENT

Experiments 1 and 1-a: (1) Is it possible for man to live on bread and water alone? Why? (2) What are the seven food substances required by the human body? (3) Does it make any difference whether foods contain

vitamins? (4) Why is scurvy prevented and cured when raw vegetables are added to the diet? (5) If a person is overweight what foods should be used sparingly? (6) If underweight, what foods should we learn to use? (7) What do you know about a balanced diet? (8) Criticize this dinner: bean soup, roast beef, baked beans, peas, tuna fish salad, bread and butter. (9) What are some good reasons why an all meat diet is inadvisable? (10) Could man wholly depend on plants for food? Why?

Experiment 2: (1) Why is agriculture the most important industry? (2) Give at least three reasons why farmers cultivate soil? (3) Land will not continue to grow the same crop year after year. Why is this so? (4) What is meant by fertility when applied to soil? (5) What is nature's plan for keeping soil fertile? (6) What are three important methods man uses to restore fertility to soil? (7) What are the chief commercial fertilizers? (8) What are the "natural" fertilizers? (9) Why is it often more beneficial to the farmer to plow the clover crop in than to harvest it? (10) What is rotation of crops? (11) What benefits are derived from rotation of crops? (12) What problem must be solved in order to produce crops in southern California? (13) How may farmers help soil retain its moisture in dry periods? (See 8th Grade Course, "Gardening," Experiments 5 and 5a.) (14) How does capillarity apply to soils? (See 8th Grade Course, "Earth's Crust," Experiment 6-a.)

Development for "Gregor Mendel's Discovery and What Came of It": (1) What did Gregor Mendel find out in his garden? (2) By naming plant and animal traits illustrate what is meant by heredity. (3) State Mendel's law of unit characters, giving examples that illustrate its working. (4) What is meant by "hybrids"? (5) State Mendel's law of dominance, giving examples. (6) What "dominant" traits have you discovered in yourself? (7) Have you discovered any "recessive" characters? (8) State Mendel's law of segregation, giving examples. (9) Draw a diagram which will explain the workings of the Mendelian laws. (10) How are desirable qualities secured in plants and animals through the application of the laws of heredity? (11) What are some food products we would not enjoy today if the Mendelian laws had never been discovered? (12) What great American scientist is thought of in connection with the Mendelian law?

Experiment 3: (1) What effect has the atmosphere and dust particles about us upon the food which we eat? (2) What things that are commonly used by you should be carefully sterilized? (3) Mention foods which you think are most susceptible to bacteria growth? (4) What methods of sterilization of food do you know?

Experiments 4, 4-a and 4-b: (1) Why should classrooms and lunchrooms have their floors cleaned and oiled frequently? (2) What are the most prevalent sources of bacteria? (3) Why are bacteria called micro-organisms? (4) What harm is produced by bacteria in foods? Why? (5) Why do pickles "keep"? (6) Why do fruit juices "keep" when made into jam and jellies? (7) Why do dried beef and dried fruit remain good longer than the fresh articles? (8) Why are canned goods subjected to boiling before being distributed for sale in grocery stores? (9) Who first discovered the effectiveness of boiling as a sterilizing agent? (10) Mention the most common ways in which disease germs are carried? (11) How can you justify the law prohibiting common drinking cups and towels in public buildings? (12) What are the three ways by which bacteria produce poisons? (13) How does the body protect itself from disease bacteria which have entered it? (14) Why are tears salty? (15) Do you know of any ways in which the human body is aided by doctors to resist disease bacteria? (16) Name five things each of us can do to help the body ward off diseases. (17) What are some substances that may be used to aid in destroying and combating disease bacteria? (18) If you could, would you destroy all bacteria? Why? (19) Name several industries that are dependent on the work of bacteria? (20) How is the farmer dependent on friendly bacteria?

Experiment 5: (1) In general, molds are associated with dead materials. Account for this. (2) Why is it that molds do not require green coloring matter as other plants do? (3) Why do we never need to take much care in keeping such foods as shredded wheat and corn flakes from molding? (4) What are "spores"? (5) What do they do? (6) What is the advantage of having groceries wrapped in sealed boxes or in airtight tins or glass?

Experiments 6 and 6-a: (1) Why are the spores of mold and yeast always found on objects exposed to the air, including the skins of fruits? (2) How do yeast plants get into foods? (3) How do you account for fermentation in exposed fruit juice when no yeast cake has been added? (4) What may be done to fruit juices such as grape juice and sweet cider to keep them from fermenting? (5) What conditions are necessary to produce vinegar? (6) What industrial processes are dependent on the action of yeast?

Development for Report on Insects, Birds, and Toads: Some insects and diseases are close companions. (1) Explain this statement, giving examples. Recall 8th Grade Course, "Plant Friends and Plant Enemies," Experiment 3-a and answer the following questions: (2) Why are house flies dangerous? (3) Mosquitoes? A knowledge of the life history of an insect will help us to get rid of it. (4) Explain how this fact applies to mosquitoes and house flies. (5) Are all insects bad? Give examples. (6) Men must protect the birds. Why? (Recall 8th Grade Course, "Plant Friends and Plant Enemies," Experiment 5a.) (7) Which birds are protected by law in Pennsylvania? Why? (8) Every toad living on a farm or garden is said to be worth \$25.00. Why? (Recall 8th Grade Course, "Plant Friends and Plant Enemies," Experiment 4.)

Experiments 7 and 7-a: (1) Why do we wrap a piece of ice in a blanket to keep it cold, but wrap a person in a blanket to keep him warm? (2) Why is it that athletes don a woolen garment after a race? (3) Why do icemen and firemen wear woolen shirts even in summer? (4) Why are bathing suits made of wool instead of linen? (5) What are the five most important sources of clothing fabrics? (6) Which of these are animal products? (7) What are the principal uses of artificial silk? (8) What are some of its advantages and disadvantages as a textile fiber? (9) What fibers, besides the four common ones, are sometimes used for weaving coarse cloth, making twine, etc.? (10) What do the following terms mean when applied to cloth: warp, woof, selvage?

SUMMARY

Food substances required by man are proteins or *nitrogen* compounds; carbohydrates or *sugars, starches; fats and oils; vitamins; acids; mineral salts; and water* as the solvent. Many of the *fats* and *proteins* come from animal products.

A balanced diet is one which has the proper *proportion* of all the *seven* food substances required by the human body.

Food substance	Examples	Usefulness to body
proteins	meat, beans, nuts	energy and body building
carbohydrates	candy, corn products	body building
fats and oils	butter, olive oil, nuts	heat producing
vitamins	raw fruits and vegetables	stimulates body processes
acids	fruits	used in secretions
mineral salts	milk, green vegetables	bone growth
water		solvent for food materials and waste materials

Agriculture is man's most important industry because all *food* for animal life depends on *plant* life and *plants* thrive in fertile soil.

Fertile soil is soil containing the necessary *mineral* salts required by *plants* to *manufacture* food substances.

Fertility may be maintained in soils by proper *rotation* of crops, proper supply of water (*irrigation*), and the application of proper natural or artificial *fertilizers*.

All plants do not take the same mineral salts from the soil. Rotation of crops permits *two* crops to be grown without sacrificing soil *fertility*. It also economizes *land* used.

Soil cultivation distributes *fertilizers* to plant roots, permits *air* to reach plant roots and conserves soil water in *dry* seasons.

Gregor Mendel's Discovery

Heredity is the transmission of some of their own *characteristics* from *parents* to their *descendants*.

Man has used Mendel's laws of unit characters, of dominance, and of segregation to produce new *plants* and to improve man's *plant* and *animal* products. These laws were used by *Luther Burbank* to produce useful new *plants*.

In man, *good* and *bad* traits are passed on from parents to descendants. When these traits are always evident they are called *dominant*. When they *skip* a generation they are called *recessive*.

The micro-organisms *bacteria*, *molds*, and *yeasts* are the chief causes of the destruction of food which could otherwise be used by man.

Foods may be protected by *refrigeration*, by using *preservatives*, and by *sterilization*. The only method which will safely *destroy* micro-organisms in food is *sterilization*.

Certain micro-organisms, mostly *bacteria*, are the chief causes of disease. These may cause disease by creating poison in *foods*, by creating a poison in the *body*, or by causing the *body* to create a *poison*.

The best guards against disease infection are *cleanliness*, *sunshine*, fresh *air*, and good *bodily health*.

Fortunately most of the micro-organisms are helpful. Many are essential to the enrichment of the soil, the destruction of *dead matter*, and the production of *food*.

Review 8th Grade Course, Unit VIII—"Plant Friends and Plant Enemies," Experiments 3, 4, and 5.

Plant and animal fibers (See also "Museum Lessons" on this topic in Appendix).

Clothing protects the body from *weather* by helping to *regulate* bodily *heat*.

Fabrics like wool which hold large quantities of *air* between the *fibers* keep the body warmest.

The chief clothing fabrics, beginning with the one that keeps the body warmest are *fur*, *wool*, *silk*, *cotton*, *linen*.

Only fibers having a *curl* or *twist* can be *spun* into yarn and thread for weaving cloth. Hemp, jute, and sisal, which are *coarse* plant fibers, are used for making ropes, twine, and burlap.

Our dependence on trees.

Review 7th Grade Course, Unit VIII—"Flowers and Plants," Experiment 6.

UNIT VIII

RELATION OF MAN TO HIS ENVIRONMENT

GENERAL OBJECTIVES

The important concept is to show that man may, to a great extent, control his own welfare. Emphasis has therefore been placed on the importance of pure food, the dangers of stimulants and narcotics, the prevention of disease, and the importance of being well-born.

SPECIFIC OBJECTIVES	PROBLEMS FOR EXPERIMENT	DESIRABLE OUTCOMES
Dangers in Man's Food Supply Food Protection	1. How can adulterations and substitutions in some foods be detected? (group experiment) 1a. What substances are sometimes sold as fruit jellies, fruit jams, and ice cream? (group experiment) 1b. How can we know whether an egg is fresh? (group experiment)	Realization that wholesome food, pure water, and control of epidemic diseases are necessary to the health of the community.
Injurious Stimulants and Narcotics	2. Are alcoholic beverages safe to use? (group experiment)	Knowledge: 1. Of the danger to health in foods containing harmful drugs, preservatives, artificial flavors or colors. 2. That using alcoholic stimulants, drugs, and patent medicines without a physician's advice is dangerous.
Dangers of Epidemics The Scientific Conquering of Disease	* "Dr. Edward Jenner's Discovery of Small Pox Control" * "Louis Pasteur's Anti-toxin Discoveries" * "Dr. Reed and Dr. Lazaer's Discovery of Yellow Fever Control"	3. Healthy human bodies produce white corpuscles and natural anti-toxins as protections against disease germs. 4. Serums, discovered by Jenner, Pasteur and other skilful scientists, when injected into the blood, produce artificial immunity against many epidemic diseases.
Being Well-Born Improving the Human Family	3. Does heredity operate in my family? 3a. Is it possible to improve the human family?	Conviction that healthy parents produce healthy children; feeble-minded parents produce defective children.

NOTES ON EXPERIMENTS

Experiment 1 can be performed by using the following apparatus and following these directions: 1—Apparatus: Ground coffee; butter; pure olive oil; cottonseed or "mazola" oil; nitric acid; water; spoon; beaker; two six-inch test tubes; Bunsen burner. 2—Directions and observations: (a) Coffee: Spread a half teaspoonful of ground coffee over the surface of water in a beaker. Let it stand for five minutes. Note results. The particles of coffee will float. (b) Butter: Heat some butter in a spoon. Note result. If it sputters and has very little foam, it is a butter substitute. (c) Olive Oil: In one test tube put about five cc. of olive oil. In the other put an equal quantity of cottonseed oil or "mazola." To each test tube add about five cc. of nitric acid and shake. Note the color produced. Pure olive oil will turn to a dark green color in a few minutes. **Experiment 1-a** can be performed by obtaining samples of ice cream, bright colored candy or cheap jam or jelly and subject them to the following tests: **Glucose test**—Add a teaspoonful of the sample to a test tube half full of water and heat. Filter. To half the filtrate add Fehling's solution and boil. A red precipitate indicates glucose. **Starch test**—To the remainder of the filtrate add a drop or two of iodine tincture. A blue or purplish color indicates starch. **Artificial Color test**—Dissolve some jam or jelly or colored candy in an evaporating dish half full of boiling water. Boil a piece of white yarn in this for ten minutes. Remove yarn and wash it in hot water. A bright color left on the yarn indicates artificial color. **Experiment 1-b** can be performed by putting eggs in a ten percent solution of table salt. The

fresh eggs will sink. **Experiment 2** can be performed by using the following apparatus and following these directions: 1—Apparatus: Two 100 cc. beakers; two pieces of absorbent cotton; two gummed labels; fresh eggs; about 75 cc. of alcohol; equal quantity of water; match; alcohol lamp. 2—Directions and observations: Put the water in one beaker. Label it 1. Put the alcohol in the other beaker. Label it 2. (a) Examine both substances in the beakers. How do they compare in color? Could you tell which was which by looking at them? (b) Dip one of the pieces of cotton in the water and rub it for a moment on the forearm. Using the other piece of cotton, rub another part of the forearm with the alcohol. Note any difference in the sensation. (c) After the two liquids thus applied have evaporated, note any apparent change in the sensation produced by the alcohol. (d) Light the alcohol lamp. With the hands, test the warmth produced by the rapid combustion of alcohol. Divide the "white" of the egg (albumen) into two portions. (e) Put a portion of the egg albumen into the water in beaker 1. Note the effect on the albumen. (f) Put a portion of the egg albumen into the alcohol in beaker 2. Note effect on the albumen. Albumen closely resembles one of the important parts of all cell tissues composing the human body. **Experiment 3** can be performed by using the following chart in which are listed such characteristics as external physical variations including stature, color of eyes, color of hair, wink of the right or left eye, etc.; internal physical variation including pulse rate, blushing, plant or food poisoning, etc.; mental traits including excitability, neatness, humor, good taste in dress, in recreation, promptness, etc.

*Reports.

My Heredity Score Sheet

Name Section

Inherited Traits	Source					
	F.	M.	F. F.	F. M.	M. F.	M. M.
List Traits Here)						

F. —Father
M. —Mother
F. F.—Father's Father

F. M.—Father's Mother
M. F.—Mother's Father
M. M.—Mother's Mother

Experiment 3-a can be performed by making a study of charts in textbooks showing good and bad heredity so as to answer these questions: Are mental traits, both favorable and unfavorable, handed down from one generation to another? If one parent is feeble-minded, are any of the children likely to be feeble-minded or criminal? If both parents are feeble-minded, what is the probability of feeble-minded or criminal children? Does feeble-mindedness seem to be a dominant or a recessive characteristic?

DEVELOPMENT

Experiments 1, 1-a and 1-b: (1) Explain "U. S. Inspected and Passed" on labels of food products. (2) Why does the meat in the butcher shop have the Government stamp upon it which is always purple? (3) For what parasite is pork carefully examined? (4) Beef? (5) What is meant by "Grade A" milk? (6) "Grade B" milk? (7) Is cold storage food wholesome? (8) Why is egg candling an important business today? (9) What is meant by "Quaranteed Under the Pure Food and Drugs Act of 1906"? (10) What is the serious defect in this law? (11) Why is it so necessary to "read the label" before purchasing food and drug products? (12) What preservatives in canned or bottled goods should be avoided?

Experiment 2: (1) Why can we not consider alcohol as a food? (2) What is the distinction between a stimulant and a narcotic? (3) Give two illustrations of each type. (4) What are the "habit forming drugs"? (5) What is the most evil effect of the use of drugs? (6) What are the eleven drugs which the law declares must be stated on the label if present in any medicine? (7) What restrictions have been placed about their use by our state government? (8) By the United States government? (9) Through your local library or by consulting your family physician make a study and report to your class upon some important parts of one of the following books: "The Great American Fraud," "Medical Fakes and Fakers," "Nostrums and Quackery," all published by the American Medical Association, Chicago, Illinois; "Harmfulness of Headache Mixtures," by Kebler, et al., Farmer's Bulletin 377. Bulletins from *The Consumers Research*, Washington, N. J. (10) What two diseases cannot be cured by drugs

even though so-called "remedies" for them are widespread in patent medicine advertisements? (11) What are the dangerous drugs to be avoided in "headache powders" and other patent medicines? (12) How do "headache remedies" work? (13) What organ of the body do they affect? (14) Is their use safe? (15) Why is tobacco more harmful to a youth than to a mature person? (16) Some tobacco advertisements suggest tobacco as useful in combating overweight. Criticize this suggestion.

Experiments 3 and 3-a: (1) To what extent is your health a matter of inheritance? (2) To what extent is it a matter of your personal control through attention to good hygiene? (3) Which is the more powerful influence? (4) Is tuberculosis inherited? (5) What is the best safeguard to use to prevent tuberculosis from developing in the body? (6) What are the fundamental conditions for maintaining vigorous health and strong bodily resistance? (7) Why do people often speak of a boy as "a chip off the old block"?

SUMMARY

The good health of a community depends on a wholesome food supply, pure water and the prevention and control of epidemic diseases.

The Pure Food and Drugs Act of 1906 requires that the use of artificial coloring, artificial flavoring, dangerous drugs or preservatives be stated on the label of food and drug products offered for sale. To realize the benefits of this law we must always read the labels on all canned or bottled foods or medicines, and purchase only those that contain nothing harmful.

Alcoholic stimulants, drugs, and patent medicines should never be used except on advice of a reliable physician.

The use of stimulants and narcotics seriously interferes with the health of the human body, therefore with the happiness of the home, and success in finding employment and holding a position.

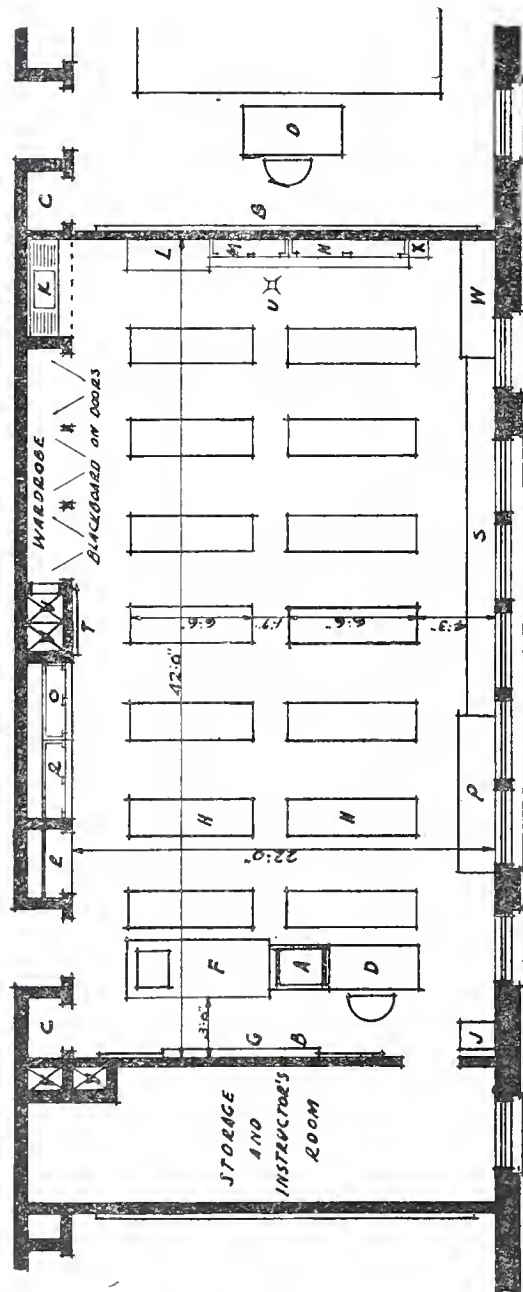
When in health the human body is naturally protected against disease germs by the action of the white corpuscles and of anti-toxins produced by the blood.

Artificial immunity can be produced against diseases like smallpox and diphtheria by injecting into the blood vaccines and anti-toxins produced in the bodies of other animals.

The skilful work of Jenner, Pasteur, Reed and Lazear, and others has been the chief cause of the control of epidemic diseases such as smallpox, hydrophobia, yellow fever, and diphtheria.

The general health and efficiency of the body depends upon proper food, proper amount of sleep, plenty of exercise in the open air, plenty of air while sleeping, and the non-use of stimulants and narcotics.

Inheritance in man works according to the Mendelian Laws. It is important to produce good families.



KEY

- A AQUARIUM
- B BLACKBOARD
- C TEACHERS CLOSET
- D TEACHERS DESK
- E BOOKCASE
- F DEMONSTRATION DESK (WATER, GAS AND ELECTRICITY)
- G PROJECTION SCREEN
- H TABLES 12"x6"x6" WITH CHAIRS (GAS DESIRABLE)
- J FILING CASE
- K SINK
- L WORK BENCH
- M STORAGE CASE
- N DISPLAY CASE
- O NOTED CASE
- P GERMINATION BED
- R MICROSCOPE AND DISPLAY CASE
- S WIDE SHELF CUPBOARD UNDER (GAS, WATER AND ELECTRICITY)
- T CORE BOARD
- U FLOOR OR BASE PLUG (DUPLEX)
- V VENT
- W CAGE FOR ANIMALS
- X SLIDE CABINET

PLAN

SCALE 1" = 1 FOOT



SUGGESTED LAYOUT FOR GENERAL SCIENCE AND BIOLOGY CLASS ROOM LABORATORY

NOTE: PROVIDE TRANSPARENT AND OPAQUE SHADES
FOR EACH WINDOW.

DEVELOPED IN COLLABORATION WITH
THE SECONDARY SCHOOL DIVISION
COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF PUBLIC INSTRUCTION
DIVISION OF SCHOOL BUILDINGS
HUBERT C. FISHER DIRECTOR
C. B. CO. J. L. S.

APPENDIX B

List of Supplies and Equipment Required for the Course of Study in Science—Grades Seven, Eight and Nine

The quantities here stated are sufficient for the following enrollment:

One section of 35-40 pupils in a room furnished with one teacher's demonstration table and pupil laboratory tables.

Article	Unit	Quantities per Grade		
		7th	8th	9th
Chemicals				
Acid, Hydrochloric, com'l, 20°, 6 lb. bottles	lb.	3		2
Acid, Nitric, com'l, 38°, 7 lb. bottles	lb.			1
Acid, Sulphuric (dilute 1 to 8)	lb.			1/8
Acid, Tartaric, U.S.P., powder	lb.			1/8
Alcohol, Ethyl, denatured, com'l.	gal.	1/4		1/4
Ammonium Hydroxide, com'l, 20°, in 4 lb. bottles, with glass stopper	lb.			2
Ammonium chloride, com'l, granular	lb.	1/2		
Ammonium Nitrate, com'l, granular	lb.			1/16
Calcium Hypochlorite, com'l.	lb.			1/8
Calcium Oxide, lump (for making lime water)	lb.	1/2	1/2	1/2
Calcium Sulphate, com'l, powder (Plaster of Paris)	lb.	1/2		
Candles, Non-drip, granite stock, 47/8" x 3/4"	lb.	1	1/2	1/2
Carbon Tetrachloride, com'l.	lb.	1		1
Cement, Portland	lb.	1		
Charcoal, animal, com'l, powder	lb.	1/2		1/4
Copper, Sulphate, com'l, crystals (Blue vitriol)	lb.		1/4	1/4
Cotton, absorbent	lb.	1		1/4
Ether, Sulphuric, U.S.P., 4% Alcohol, in 1 lb. cans	lb.	1/16		
Fehling's Alkaline Solution	liter.			1/2
Fehling's Copper Solution	liter.			1/2
Gelatine, for culture media	lb.			1/16
Iodine, U.S.P., resublimed	oz.	1/2		1
Iron Metal, com'l, filings, fine	lb.	1		1/2
Iron Metal, com'l, wire, picture cord	pkg.	1/2		1/2
Lead, Arsenate	1/4 lb.		1/8	
Manganese Dioxide, native, fine powder	lb.			1/16
Matches, Safety, Boxes	gross	1/12	1/12	1/12
Mercury, metal, U.S.P., redistilled	lb.		2	
Mercuric, Oxide, red, U.S.P., powder	lb.	1/8		1/5
Molasses	qt.			1/8
Oil, Linseed, boiled, commercial	gal.	1/32		
Paraffine, melting about 52° C	lb.	1/8	1/8	1/8
Paste, Photographic, in tubes	tube	1	1	1
Petrolatum, yellow	lb.			1/16
Phenolphthalein, U.S.P., powder	oz.			1
Potassium Chlorate, U.S.P., crystals	lb.			1/16
Potassium Chloride, pure, white, powder	lb.			1/8
Potassium Hydroxide, U.S.P., sticks, 1 lb. bottle	lb.			1/2
Potassium Permanganate, U.S.P., crystals	lb.	1/8		
Punk, Chinese, in sticks	pkg.		1/2	1/2
Rosin, yellow, lump	lb.			1/8
Sand, sea, white	bu.	1/32	1/8	1/32
Silver Nitrate, C.P., crystals	oz.			1/2
Soap, Castile, white	lb.	1/8	1/8	
Sodium Bicarbonate U.S.P., powder	lb.	1		1/16
Sodium, Carbonate, com'l, crystals (sal soda)	lb.	1/4		1/2
Sodium Chloride, commercial	lb.	1/8		1/4
Sodium Hydroxide, U.S.P., sticks, 1 lb. bottles	lb.			1/2
Sodium Sulphate, U.S.P., crystals	lb.			1/8

Article	Unit	Quantities per Grade		
		7th	8th	9th
Sodium Thiosulphate, U.S.P., crystals	lb.	.....	.....	1/8
Sugar, cane, eube	lb.	.....	1	.....
Sugar, cane, granulated	lb.	.....	.....	1
Sulphur, Flowers of, U.S.P., powder	lb.	.....	1/4	1/2
Tapers, Wax	box	1	1	1
Test Paper, Litmus, blue, 100 strips per vial	vial	.....	.....	2
Test Paper, Litmus, red, 100 strips per vial	vial	.....	.....	2
Vinegar, double strength	qt.	.....	.....	1/2
Water, distilled, in 5 gal. carboys	gal.	1	.....	1/2
Wood Splints, in bundles, 500 to bdl.	bdl.	1	1	1
Zinc Metal, com'l, mossy, about 1/2", no fine powder	lb.	.....	.....	1/8
Biological Apparatus				
Aquarium, glass, circular, with heavy welted rim, high form, 4 gal., height 10 1/2", diam. 11"		.....	1	1
Box, Germinating, Ganong pattern		.....	3	.....
Cover Glasses, Micro, squares, 18mm.	oz.	.....	.....	1
Dish, glass, Petri, with cover, diam. 10 cm.		2	4	6
Fertilizer, commercial, Nitrogen 5%, Phosphoric Acid 7%, Potash 4%	lb.	.....	1/2	.....
Fibet, Bulb	qt.	1/2	.....	1/2
Forceps, Dissecting, heavy straight corrugated points, without guide pin, length 125 mm.	pr.	.....	.....	1
Microscope, Speneer No. 64-B, equipped with double nose-piece, dust proof, one objective 16 mm. and another objective 4 mm., one eye-piece X10. Not to be supplied with diaphragms, nor sub-stage condensers, nor objective boxes nor wooden easels		.....	.....	1
Mount, Cardboard, gray, 8 ply, 8" x 12"		.....	.....	3
Needle, Dissecting straight, in wooden handle		40	2	.....
Osmosis Membrane (Gold beater's Skin), 6" square		.....	.....	1
Pebbles, for aquarium (must be small)	qt.	1/2	.....	.....
Pictures, from Jos. H. Dodson Co., Inc., Kankakee, Ill.				
American Robin List		.....	1	.....
American Crow		.....	1	.....
English Sparrow		.....	1	.....
Purple Grackle		.....	1	.....
Homing Pigeon		.....	1	.....
Goldenrod		1	.....	.....
Narcissus		1	.....	.....
New England Aster		1	.....	.....
Black Eye Susan		1	.....	.....
Pasture Thistle		1	.....	.....
Purple Violet		1	.....	.....
Dandelion		1	.....	.....
Pot, Flower, earthen, 3" top diam.		.....	3	.....
Pot, Flower, earthen, 6" top diam.		.....	1	3
Slides, Micro, 1 mm. thick, 3" x 1" Label, guaranteed non-corrosive	1/2 gross	.....	.....	1
Seeds, Oat	lb.	.....	.....	1/8
Seeds, Lima Bean	lb.	1	1	3
Seeds, Peas	lb.	.....	1/4	.....
Seeds, Radish, long white	pkg.	1/2	1/2	1/2
Watch Glass, Syracuse, with ground beveled surface for writing upon, diam. 2 5/8"		.....	2	.....

Article	Unit	Quantities per Grade		
		7th	8th	9th
Chemical Apparatus				
Asbestos Board, 4" x 4" x 1/8" .....		.....	.....	21
Balance, Cenco-Improved, Double Beam, agate bearing trip scale		1	1	2
Beaker, Pyrex glass, Griffin low form, with spout, 100 ml.	24	24	24	24
Beaker, Pyrex glass, Griffin low form, with spout, 250 ml.	24	4	24	24
Beaker, Pyrex glass, Griffin low form, with spout, 400 ml.	24	8	24	24
Bottle, white glass, wide mouth, 8 oz. "Machine Made"	4	2	4	4
Bottle, white glass, wide mouth, 16 oz. "Machine Made"	24	2	2	2
Bottle, acid, narrow-mouth, green glass with vertical glass stopper, 1 pt.	2	2	6	6
Bottle, reagent, narrow mouth, ground glass label 8 oz., label—Hydrochloric Acid HCl	1	8	8	8
Bottle, reagent, narrow mouth, ground glass label 8 oz., label—Nitric Acid—HNO ₃ .....	.....	.....	8	8
Bottle, reagent, narrow mouth, ground glass label 8 oz., label—Ammonium Hydroxide NH OH .....	.....	.....	8	8
Brush, beaker, black horsehair, conical shape with tufted end, 9" long, wooden handle	1	1	1	1
Brush, test tube, tinned iron wire, 9" long, bristles 1 1/4" dis. x 2 1/4" long tufted bristle end	8	8	8	8
Burner, Bunsen, 5 5/8" high, 7/16" tube	23	23	23	23
Clamp, burette, rubber covered jaws, adjustable to any angle, distance center of support to center of jaws, 4 1/2"	24	24	24	24
Clamp, Mohr pinchcocks, 2 1/2" long	1	.....	2	2
Cork, XXX quality, regular length, No. 7	6	42	1	1
Cork, XXX quality, regular length, No. 11	6	6	1	1
Cork, XXX quality, regular length, No. 14	6	6	2	2
Cork Borers, set of six, brass tubing, 3/16" to 13/32"	1	1	1	1
Cylinder, graduated, with spout, single graduations, Exax with zero at bottom, graduation interval 1 ml. capacity 100 ml. ....	.....	8	21	21
Dish, porcelain, evaporating, 60 ml., diam. 70 mm. ....	.....	.....	21	21
File, triangular, 6" long	8	8	8	8
Filter Paper, pack of 100 sheets, American Standard or equivalent, 180 mm. diam.	1	1	1	1
Flask, Florence, Pyrex glass, flat bottom, vial mouth, 500 ml. ..	21	1	21	21
Funnel, glass, short stem, approx. 60 degree angle, diam. 4". stem 4 1/2"	22	1	8	8
Gauze, wire, iron, squares, 5" x 5", 20 mesh	22	8	22	22
Jar, stone ware, without cover, 2 gal.	1	1	1	1
Knife, 3 1/2" blade	8	8	1	1
Mortar, Coors porcelain, with spout and pestle, rough inside, end of pestle unglazed, outside diam. 200 mm.	1	.....	1	1
Pipette, Dropping, "medicine dropper", length 5 1/2"	8	8	21	21
Plate, glass, square, edges not ground, 4" x 4" .....	.....	8	8	8
Ring, cast iron, for iron supports, distance support to center of ring 4 1/2", inside diam. 3 1/4"	21	21	21	21
Rubber Stopper, regular shape, one hole				
#4	lb.	2	2	2
#5	lb.	1	1	1
#8	lb.	1	1	1
#10	lb.	1	1	1
Rubber Stoppers, regular shape, two holes				
#4	lb.	1	1	1
#5	lb.	1	1	1
#6	lb.	.....	1	1
#8	lb.	.....	1	1
Spoon, horn, length 150 mm.	1	1	1	1
Spoon, Deflagration, iron, diam. bowl 1 1/2", handle 16" long ..	.....	.....	1	1
Support, iron, without fittings, base 5" x 8", rod 20" x 3/8" ..	24	24	24	24

Article	Unit	Quantities per Grade		
		7th	8th	9th
Support, Test Tube, wooden, single deck, single row, 6 holes of 22 mm. diam.		21	8	21
Thermometer, double scale, engraved on stem, diam. 1/4", minus 10 to 110 degrees C. and 10 to 220 degrees F.		23	23	23
Tongs, Crucible, double bent, wrought steel, nickel plated, length 9"	pr.	.....	.....	1
Tripod, cast iron, 9" high, inside diam. ring 3 1/2", outside diam. 4 1/4" ....		.....	.....	1
Trough, Pneumatic ....		.....	.....	20
Tube, funnel, thistle top, straight, length 250 mm. outside diam. stem at least 7 mm.		2	8	21
Tube, Pyrex Ignition, thick wall with lip, length 150 mm. outside diam. 18 mm. ....		.....	.....	21
Tubes, test, with lip, strain finder tested, outside diam. 12 mm., length 100 mm.	100	1/2	.....	1
Tubes, test, with lip, strain finder tested, outside diam. 20 mm., length 150 mm.	100	1/2	1/2	1/2
Tubes, test, with lip, strain finder tested, outside diam. 25 mm., length 200 mm.	100	1/2	.....	1/2
Tube, T shape, bore 5 mm., length of arm 38 mm.		1	.....	2
Tubing, glass, bending, thick wall, outside diam. 7 mm., tolerance 1/2 mm.	lb.	3	3	3
Tubing, rubber, F.S. pure gum, black, bore, 3/16", wall 5/64"	ft.	3	3	3
Tubing, rubber, white, cloth, wrapped, thick wall, bore 1/4", wall 1/8"	ft.	48	48	48
Watch Glass, diam. 75mm.		1	.....	2
Weight, single piece, 1 lb. with hook ....		.....	2	2
Wing top, for Bunsen burner of 7/16" tube ....		.....	.....	.....
Physics Apparatus				
Balance, Spring, English and Metric, 0-64 oz., 0-2000 gm. ....		.....	2	8
Ball, rubber, hollow, 2 1/2" diam.		7	.....	7
Ball, rubber, hollow, 4" diam.		7	.....	.....
Ball, Volley ....		.....	1	.....
Ball, Volley, bladder for ....		.....	1	.....
Bar, compound		7	.....	.....
Bell, Electric, wood base, 2 1/2", "Regular" ....		.....	3	.....
Carbons, for arc lamp, length 6", diameter 3/8", (pkg. of 10) ..		7	2	.....
Dry Cell, #6		3	4	6
Chart, Metric, width 50", ht. 46" ....		.....	.....	1
Chimney, Argand, straight ....		.....	8	2
Coil, tuning ....		.....	1	.....
Conductometer, hexagonal combination ....		.....	.....	2
Cork Dust, fine	Carton	.....	.....	1
Detector, crystal, complete with crystal ....		.....	1	.....
Electrolysis Apparatus, Brownlee Form (without jar or test tubes) ....		.....	.....	1
Faucet (cut so as to show valve in side view)		1	.....	.....
Glass, Jelly, 1/2 pt. (with lid)	10	.....	2	8
Glass, Reading, diam. 1 3/4"	21	.....	21	21
Globe	1	.....	.....	.....
Hammer, Claw, cast steel, 13 oz.	1	.....	1	1
Jar, Battery, white glass, height 200 mm., 150 mm.	1	.....	2	8
Lamp, Pocket Flash, length 6 1/2"	8	.....	.....	.....
Lamp, Pocket Flash (dry cell for) ....	.....	.....	.....	.....
Lamp, for Pocket Flash ....	.....	.....	.....	.....
Magnet, Bar 19 x 6 mm., length 15 cm.	22	.....	2	22
Magneto Electric Generator, with lamp ....	.....	.....	1	.....
Measure, liquid, 2 pts. ....	.....	.....	.....	7
Measure, liquid liter, tinned iron, spout and handle ....	.....	.....	.....	7

Article	Unit	Quantities per Grade		
		7th	8th	9th
Meter Stick, maple, brass tips, English and Metric graduations		1	8	8
Mirror, Plane 6" x 4"				7
Motor, Little Giant, assembled			1	
Needle, Magnetic, 6"		8		
Plane, Inclined, Car for, four wheels			1	
Pliers, Gas, 8" long		1	1	1
Pliers, side cutting, 5"		1	1	1
Prism, glass, right angled, wide face, 32 x 50 mm.		7		
Pulley, Single			2	
Push Button, wood,		1	3	
Rubber Dam, thickness No. 31 B & S gauge	sq. ft.	1	1	
Rule, wood, 12", English and Metric			40	40
Screw Driver, Electrician's Champion, insulated blade, length of blade 3 1/2"		1	1	1
Solder, half and half, wire	lb.	1/4		
Switch, knife, porcelain base, single pole, single throw, 25 amp.			1	
Telephone receivers, Baldwin	pr.		1	
Telephone transmitter			1	
Thread, linen, black #30		1	1	1
Tool set, Hollow Handle, 9 tools	set	1	1	1
Tube, Barometer, length 80 cm., 6mm., bore,			1	
Tuning Fork, unmounted, 256 vibrations per sec.			7	
Velveteen, black, 36" wide	yd.			1
Wire, Annunciator, No. 18, 1 lb. spool	spool	1/2	2	
Wire, Copper, Cotton Covered, Spool No. 20	spool		1	
Wire, Copper, bare, 1/4 lb. spool, #36	spool	1		
Wire, Iron, japanned 1/4lb. spool, #18	spool	1/4		1/4
Zinc, sheet, 1/32"	sq. ft.	3 1/2		10 1/2

Miscellaneous

Boards, Card, White, 22" x 28"	sheets	3		6
Cheesecloth	yd.	1	1	1
Cord, cable	ball		1	
Dish, soup, white				7
Ink, Crimson	pt.	1/4	1/4	
Labels, gummed, narrow	box	1	1	1
Oil, olive, must be pure (table use)	pt.		1/4	
Pan, agate, 2 qt.			1	1
Paper, cross section, Manila 9" x 12"	ream		1/4	
Paris Green	lb.		1/16	
Jar, qt. size, Mason type		2	2	
Jar, pt. size, Mason type				3
Scissors, 5"	doz.		1/4	
Sewing needles		21		8
Shakers, salt, 3"	doz.	2/3	1/4	
Window glass, 8" square	pc.	21		8

NOTE

1. Lime Water

In a glass bottle or jar place 1/4 pound of calcium oxide. Cover with 2 quarts distilled water. Stir and allow to settle. Pour off or filter the clear lime water. Lime water should not be exposed to the air nor be kept in an open bottle.

2. Iodine Solution

Dissolve a few flakes of iodine in a bottle containing denatured alcohol. Add sufficient iodine to make the solution the color of a strong tea infusion.

3. United States Weather Maps

Write to the nearest United States Weather Bureau Station.

4. *Glass Stirring Rods*

These can be made from glass tubing, by closing each end of a ten inch length of tubing in a Bunsen flame.

5. *Alcohol for Lamps*

If alcohol lamps are to be used instead of Bunsen burners allow about one pint of alcohol per lamp per semester. (Alcohol lamps wick $\frac{1}{2}$ " diam. are 75c each.)

6. The list of supplies does not include specimen of rock, soil, and articles or substances which the children will be glad to bring, such as eggs, flowers, string, tin cans, etc.

7. The total cost of the apparatus for each of the grades is as follows:

Grade 7—\$165.00

Grade 8— 155.00

Grade 9— 290.00

This includes biological, chemical and physics apparatus and certain of the miscellaneous supplies. If the apparatus is available to all teachers of science, a considerable saving can be effected where duplication in the various grades is involved. By ordering the largest number of units of apparatus suggested in any grade the cost can be reduced by one-half or more.

The cost of consummable supplies for each classroom is approximately as follows:

Grade 7—\$14.00

Grade 8— 16.00

Grade 9— 15.00

APPENDIX C

Visual-Sensory Aids in Junior High School Science

Science is a subject that is mastered largely through experimentation and investigation. To conduct the essential experiments and investigations in this field, visual-sensory materials and their accompanying procedures are necessary. These visual-sensory materials and procedures are only briefly described in this section. While some sources are indicated, the responsibility for knowing where to procure materials, and when and how to use them effectively must be assumed of teachers and should be part of their preparation.

A fundamental principle in the use of visual-sensory materials is that the child shall be an active agent. Since investigation in the junior high school science field will require keen observation, it is well for teachers to remember that meaningful observation involves more than merely looking at something. Pupils must not only see; they must interpret, if they are to understand.

The course herein outlined sets up many experimental studies. These will require apparatus and equipment. Visual instructors in the teacher preparation institutions of the State have set up a minimum amount of standard apparatus and equipment that should be available to teacher and pupils in junior high schools. The supplying of this material to schools is a responsibility of the board of education. In Appendix B of this bulletin will be found the minimum standard equipment for junior high schools.

A second visual-sensory medium that contributes largely to the junior high school science field is that of the School Journey. This means that where instruction can be more effectively given, school groups shall be taken to the zoo, the museum, the weather bureau, the field, the woods, the industry, rocks, soil, water, air, etc., or wherever phenomena and science situations may be seen and studied in their natural settings. Teachers should know how to organize, conduct, and check school journey work in connection with this subject. This information is supplied in the *School Journey Bulletin* published by the Department of Public Instruction.

A third valuable visual-sensory aid is the Object-Specimen-Model. This means a lesson at a natural science museum, the bringing into the class-room of an animal, an insect, cocoon, or anything in the science field where pupils will be permitted to observe certain characteristics, etc., or the experiments dealing with matter, energy, heat, sound, light, magnetism, electricity, machines, etc., that require definite apparatus equipment, or models. It will be seen that a very definite technique in the use of this procedure is necessary on the part of the teacher. This information is supplied in the *Object-Specimen-Model Bulletin* published by the Department of Public Instruction; in Appendix A—museum lessons; Appendix B—plants, products, and state forests; and in the wealth of suggestions contained in the pages of this bulletin.

Pictorial Material also has its contribution to make to an understanding of science. There is a wealth of flat pictures, stereographs, slides, films, etc., in this field—some of them

absolutely necessary to effective instruction and learning. Charts also make a valuable contribution to this field. Teachers should not only know this material but they should be familiar with standards for evaluating pictorial materials. Modern educational procedures require that teachers know how to relate pictorial materials definitely to the curriculum and how to use them effectively in the instructional and learning processes.

Radio is with us and has recognized values. The organized programs in the field of science have contributed to the development of radio-vision which means that teachers use pictorial and object materials to visualize what comes over the radio. This activity is growing rapidly. Teachers are advised to keep in close touch with its development. In schools in which there are receiving sets, teachers should take advantage of the available program materials.

The following Museum Lessons are suggestive of techniques which may also be applied to other fields:

GUMS, RESINS, AND RUBBER (MUSEUM LESSON)

A. Problem

How do we obtain and use gums, resins, and rubber?

B. Experiment

1. Apparatus

Three beakers; teaspoon; pencil or stick; two 6-inch test tubes; alcohol; water; specimens of gum tragacanth, copal, rosin, rubber milk (latex), plantation rubber, acetic acid.

Part 1—Gums

2. Directions

- Examine dry piece of gum arabic. Taste it. Does it dissolve?
- Examine a piece of gum arabic which has been placed in beaker of water 2 hours previously. What has happened to the gum?

Place a piece of gum tragacanth about the size of a pea in beaker of water 2 days previous to the lesson. Note effect on gum.

- Examine dry piece of gum size of a pea. Compare with soaked gum as to size.

3. Conclusions

Which of the 2 gums is a true gum?

C. Development—Subject Matter

1. Occurrence

Gums are found in thorny shrubs or trees on edges of deserts in Asia and Africa. Injury to the bark allows air and bacteria to reach cells containing sap. Action of air and bacteria on the sap forms the gum.

2. Uses

To the plant—protection to wound in bark.
To man—Mucilage; in candy (marshmallow);
water colors; stiffening of fabrics.

D. Summary

True gums are *soluble* in water.
Many substances are inaccurately called *gums*.

Part 2—Resins

A. Problem (stated at beginning of lesson)

B. Experiment

1. Apparatus (listed at beginning of lesson)

2. Directions

- Examine pieces of rosin and copal, noting color and comparative hardness.
- Place a piece of rosin in one test tube containing water and another piece in a test tube containing alcohol. Shake. Which dissolves?

3. Conclusions

How can you distinguish a rosin? See Ninth Grade Course, Common Elements and Compounds, Experiment 2.

C. Development—Subject Matter

1. Occurrence

Resins are the result of evaporation of watery and volatile oils in sap of certain trees. Rosin is the resin of longleaf yellow pine found in southern U. S. and Europe. Copals are hard resins, some of fossil origin found in Africa, New Zealand, and the Philippines.

2. Uses

To the plant—Gives strength to the wood.
To man—Mostly used in preparation of varnishes.

D. Summary

Resins are soluble in *alcohol* or *turpentine* but not in water.

Resin and rosin are not *synonymous*.

Part 3—Rubber

A. Problem (stated at beginning of lesson)

B. Experiment

1. Apparatus (listed at beginning of lesson)

2. Directions

- Examine the rubber latex in a beaker. Describe it.
- Add 3 teaspoonsful of acetic acid and stir with a stick. Results?
- Examine specimens of plantation rubber and of rubber articles (vulcanized rubber). How do they differ from the crude rubber?

3. Conclusions

Can rubber be used as it comes from the tree? Why? What must be done to it to form crude rubber?

C. Development—Subject Matter

1. Occurrence

Rubber is made from a "milk," not sap, obtained by tapping the outer portion of the bark of the Hevea tree, native to Brazil, but cultivated in Malaysia, East Indies, Ceylon, Philippines.

Vulcanization—addition of sulphur to the rubber to prevent stickiness. The amount of sulphur added differentiates *soft* rubber from *hard* rubber.

2. Uses

To the plant—Unknown.

To man—After coagulation and vulcanization rubber is used for automobile tires, electrical insulation, overshoes and waterproofs, erasers, etc.

D. Summary

Rubber is not a *sap* nor *gum*.

Rubber is prepared from a "milk" or *latex* found in certain tropical trees.

CELLULOSE PRODUCTS
(MUSEUM LESSON)

A. Problem

What are cellulose products and how are they made?

B. Experiment

1. Apparatus

Reading glass; large beaker; electric iron; wood frame 6 inches by 4 inches with a fine mesh screen wire top; glass rod; micro slide; hot water; 2 cups of shredded blotting paper; collodion; cotton wool; specimens of wood chips, cotton linters, dry wood pulp, celotex, rayon, photographic film.

2. Directions

Examine the cotton wool, cotton linters, wood chips, and dry wood pulp from which cellulose pulp is made.

- Using the reading glass, examine the torn edge of a piece of blotting paper. Note the arrangement of the cellulose fibers composing the blotter.

By soaking and macerating the shredded blotter in hot water, make a beaker full of cellulose pulp.

- Spread a coating of the wet pulp about $\frac{1}{8}$ inch thick over the screen wire of the wood frame. Smooth and dry it out evenly by passing the hot iron over it. When cool remove the sheet from the screen. What have you produced? Examine it.
- Examine the celotex with the hand lens. Of what does celotex seem to be made?
- Examine collodion, noting its physical condition. Rayon before being spun and hardened looks something like collodion.
- Note the odor of collodion.
- Collodion is gun cotton dissolved in chloroform. With the glass rod smear a coating of collodion

on one side of the micro slide. Set aside for 5 minutes. Result?

- g. Peel the hardened strip of collodion from the slide. It is now essentially the same as celluloid. Note its transparency and flexibility. Examine the rayon and photographic film. These are essentially celluloid.

3. Conclusions

Of what are cellulose products made?

C. Development—Subject Matter

1. Occurrence

The sources of most cellulose are cotton fiber and linters, corn stalks and wood pulp.

2. Uses

To the plant—Cellulose forms the structure of plant cell walls.

To man—Wood and rag pulp is made into paper, cardboard, and wallboard (beaver board, compo board, celotex).

By one kind of chemical treatment cellulose is made into a liquid. When this is spun into a filament and hardened rayon or artificial silk is produced. When poured into sheets and hardened cellophane is produced.

By special chemical treatment of cotton with sulphuric acid the explosive gun cotton is produced. By treating gun cotton with chloroform celluloid is made. Celluloid is the basis of photographic film, pyralin, etc.

D. Summary

Cellulose Products

From *wood* pulp, *cotton* linters and fibers, and *corn* stalks cellulose is obtained for making paper. By chemical treatment *rayon*, *cellophane*, and *celluloid* are made.

DISTILLATION PRODUCTS—ESSENTIAL OILS

(MUSEUM LESSON)

A. Problem

How are essential oils obtained from plants?

B. Experiment

1. Apparatus

Two 6-inch test tubes; test tube holder; Bunsen burner; water; specimens of yellow pine wood chips, spruce needles, camphor gum.

2. Directions

Recall Seventh Grade Course, Unit VII; Ninth Grade Course, Unit VI, Experiment 4, to review the processes involved in distillation.

- a. Put yellow pine chips in a test tube to the depth of $\frac{1}{2}$ inch and heat over the Bunsen flame. As soon as fumes are given off, note the odor. This is creosote.

- b. Note also what collects in the cool, upper end of the test tube. This is wood tar.

- c. Put spruce needles in the other test tube to the depth of 1 inch. Cover with water and heat to boiling. Note odor of volatile oil given off.

- d. Examine the specimen of camphor gum. This is a volatile oil distilled from camphor tree leaves.

3. Conclusions

How are essential oils usually obtained? What is a volatile oil? (Consult dictionary).

C. Development—Subject Matter

1. Occurrence

Essential oils are obtained mostly by distilling the wood, leaves, and flowers of certain plants.

2. Uses

To the plant—Probably protect from insects in stem and leaves. Attract them to flower.

To man—Some essential oils used as flavoring and perfume are obtained from flowers. Turpentine, rosin, creosote, wood tar, and pitch used in industry are products of distillation of pine woods. Wood alcohol and acetic acid are made by distilling waste wood. By distilling leaves of a Japanese tree camphor, a medicine is produced.

D. Summary

Essential oils are obtained by *distillation*. Some important essential oils are *creosote*, *wood* tar, *camphor* gum.

VEGETABLE OILS

(MUSEUM LESSON)

A. Problem

How are some important vegetable oils obtained?

B. Experiment

1. Apparatus

Lid from baking powder can; 4 pieces of loosely woven cotton string; match; piece of unglazed paper; specimens of cotton seed; cotton seed oil, copra, coconut oil, linseed oil.

Part 1—Non-drying oils

2. Directions

- a. Place a few peanuts between folds of unglazed paper and pound them. Note evidences of oil on the paper.

- b. Cut a piece of copra, rub it between the fingers. Result?

Pour a small quantity of cottonseed oil in the tin lid. Place one end of the string in it. Rest the lid on a piece of metal such as the base of an iron support.

- c. Light the end of the string. Result?
Arrange the specimens of cotton seed and copra with the oils which come from them.

3. Conclusions

What method is employed to extract vegetable oils? Which of the specimens studied contain most oil?

C. Development—Subject Matter**1. Occurrence**

Most vegetable oils are stored in seeds and fruits of various plants. Among the non-drying varieties are oils obtained from the olive, peanut, cotton seed, coconut, palm.

2. Uses

To the plant—The oil stored in the seed and fruits is food for the developing young plant.

To man—For food and soap making—olive, peanut, cottonseed, coconut, palm.

Recall "Relation of Plants and Animals to Man," Experiment 1, and "Common Elements and Compounds," Experiment 11b.

In oriental countries vegetable oils are also used for burning purposes.

At ordinary temperatures some oils like cottonseed oil are solids, while others like coconut oil are liquid. Oils are extracted by pressure.

D. Summary

Non-drying oils such as *olive* oil and *peanut* oil are used by man for *food* and *soap* making.

Part 2—Drying Oils**A. Problem (stated at beginning of lesson)****B. Experiment**

Recall 8th Grade Course.

C. Development—Subject Matter**1. Occurrence**

The most important "drying" oil is linseed oil obtained from flaxseed.

2. Uses

To the plant—Food for the developing young plant.
To man—Used for making paint. Recall 8th Grade Course.

D. Summary

The most important drying oil is *linseed* oil obtained from *flaxseed*. It is used for making *paint*. The drying of such oil is really *oxidation*.

VEGETABLE FIBERS**(MUSEUM LESSON)****A. Problem**

How do we prepare vegetable fibers for use?

B. Experiment**1. Apparatus**

Large beaker of water; specimens of seed cotton; ginned American Upland cotton; Sea Island cotton; Peruvian cotton; flax stems; cleaned and combed flax fiber; sisal fiber; celery stalks.

Part 1—Seed Hairs**2. Directions**

a. Take up the specimen of seed cotton. With the fingers remove the seed from the seed hair

coating. Is the process easy or difficult? Take a small portion of the Upland cotton and smooth the fibers out by pulling between the thumb and fingers. Do the same with portions of Sea Island cotton and Peruvian cotton.

b. Note the comparative length of fiber in the 3 specimens. Sea Island cotton fiber usually averages 2 inches.

c. Compare the fineness and softness of the 3 kinds of cotton. Hold the remaining specimen of Upland cotton in one hand. With the free hand begin spinning the cotton by twisting a small portion of the fiber between the thumb and 2 fingers. Keep continually twisting and pulling without letting go until you have spun a few inches of yarn.

3. Conclusions

Why are Sea Island and Upland cotton the most useful for weaving? Recall "Relation of Plants and Animals to Man," Experiment 7, Part 2. Why does cotton fiber spin so readily?

C. Development—Subject Matter**1. Occurrence**

Seed hairs are familiar on milkweed, thistle, dandelion, and cotton seeds.

Cotton is the seed hair from cotton grown in our southern states (Upland cotton and Sea Island cotton), Egypt, Peru, and China.

2. Uses

To the plant—A device to aid in scattering the seeds by the wind.

To man—Raw cotton is a soft filling for pillows, pads, quilts, etc.

Long fibered cotton is spun into yarn and thread and woven into fabric.

The advantages of cotton for fabric are:

- It is easily cleaned.
- The thinness of the fiber makes possible weaving of fine fabrics for hot climates.
- It can be treated (mercerized) to resemble silk, linen, or wool.

Coarse fiber cottons are used to mix with wool and to weave into carpets.

D. Summary

Cotton is the only seed *hair* that can be *spun* well. The *longer* the fiber the more useful it is for *spinning*. Yarn spun for weaving is *loosely* twisted fiber. Thread spun for sewing is *tightly* twisted fiber.

Part 2—Bast Fibers**A. Problem (stated at beginning of lesson)****B. Experiment**

- Apparatus (listed at beginning of lesson)

2. Directions

Take some of the flax stems from the beaker of water where they have been retting (soaking) for a day.

- a. Break the stem structure by twisting between the fingers. What is the result? The fibers that remain are linen.
- b. Spin some of the cleaned and combed flax fiber with the thumb and fingers.

3. Conclusions

How are linen bast fibers freed from the stem? Why is the process of retting necessary when preparing linen fiber?

C. Development—Subject Matter

1. Occurrence

Bast fiber is the stringy inner bark of certain woody stemmed annual plants. The most useful bast fibers are linen made from the flax plant, which is grown in Ireland and the Baltic countries, and jute which comes from India.

2. Uses

To the plant—Bast fiber toughens the bark.

To man—Linen is the best fabric for warm climates. Recall again Experiment 7, Part 2. Before linen fiber can be used it must be retted to soften the bark tissue and combed to clean the fiber. Jute is used for making burlap and gunny sacks, carpets and rugs.

D. Summary

Linen and jute are *bast* fibers from the inner *bark* of the plant stem.

Part 3—Structural Fibers

A. Problem (stated at beginning of lesson)

B. Experiment

1. Apparatus (listed at beginning of lesson)

2. Directions

- a. With the finger nail or a dull knife blade crush the celery stem. Result? Which way do the structural fibers extend in the celery stem?
- b. Examine the sisal fiber. Pull on it to test its strength. Result?

3. Conclusions

What are structural fibers like? How are structural fibers freed from the stem? Why is sisal fiber so useful for making strong twine?

C. Development—Subject Matter

1. Occurrence

Structural fibers are found within the stem or leaves of plants. The most useful structural fibers are sisal which comes from Mexican plants akin to the yucca, and "Manila" hemp which comes from plants which grow in the Philippines.

2. Uses

To the plant—Structural fibers strengthen stems and leaves of plants.

To man—Sisal is used to make the strongest twine. This is binder twine used in binding sheaves of wheat. Hemp is used for making rope.

D. Summary

Sisal and hemp are *structural* fibers from *within* the plant itself.

ANIMAL FIBERS

(MUSEUM LESSON)

A. Problem

What use do we make of animal fibers?

B. Experiment

1. Apparatus

Compound microscope; 2 micro slides; 2 large beakers; iron support with ring; wire gauze; Bunsen burner; pencil; soapy water; balance with weights; water; specimens of goat hair, rabbit fur pelt, merino wool, crossbred wool, combed wool, silk cocoon, raw silk.

Part 1—Hair

2. Directions

Place a single filament of goat hair, rabbit fur, and combed wool on a micro slide. Cover with another micro slide.

- a. Examine under the low power of the microscope. Which filament is coarse and smooth surfaced? Which is covered with fine scaled fibers?

3. Conclusions

What is the essential difference between hair and the other 2 animal fibers?

C. Development—Subject Matter

1. Occurrence

Hair is coarse, smooth surfaced fibers covering the bodies of animals. Mohair and cashmere are hair fibers from East Indian goats. Alpaca is hair fiber from the South American llama. Camel's hair comes from Asia.

2. Uses

To animals—Helps to retain bodily heat.
To man—Goat hairs are spun into coarse yarns and woven into coarse fabrics, blankets, and carpets.

D. Summary

Hair is coarse, *smooth* surfaced fibers from animals. It is suitable for weaving into *coarse* fabrics, *blankets*, and *carpets*.

Part 2—Fur

A. Problem (stated at beginning of lesson)

B. Experiment

1. Apparatus (listed at beginning of lesson)

2. Directions

- a. Examine the rabbit fur pelt. The fur is nearer the skin. The hair extends beyond the fur

Which is the softer? Which is the shorter fiber?

3. Conclusions

Recall the conclusions to Part 1. Why would fur mat easier than hair? What is there about fur that would make it difficult to weave?

C. Development—Subject Matter

1. Occurrence

Fur is very soft, fine, scale-covered fibers found lying beneath the hair on certain animals. One of the most useful furs, is that of the Australian rabbit.

2. Uses

To animals—Helps retain bodily heat.

To man—Fur, because of the plate-like scales on the fiber surfaces mats easily upon being beaten to form felts for hat manufacturing.

D. Summary

Fur is a soft, fine, *scaled* fiber found under the *hair*. By *beating*, the scaled fibers become *entangled* closely, forming a *felt*.

Part 3—Wool

A. Problem (stated at beginning of lesson)

B. Experiment

1. Apparatus (listed at beginning of lesson)

2. Directions

- a. Examine the specimens of the 3 kinds of wool. Compare with reference to length and coarseness of fiber.
- b. Compare the raw wool with the combed wool.
- c. Weigh a specimen of raw wool. Record weight. Wash it thoroughly in the soapy water. After it is dry, re-weigh it. Compare with original weight. Spin some of the combed wool between the thumb and fingers. Recall "Relation of Plants and Animals to Man," Experiment 7, Part 2.

3. Conclusions

How is the quality of wool improved by cross breeding the merino with the Lincoln sheep? One hundred pounds of raw wool is often reduced to 40 pounds after scouring and combing. Why is it necessary to scour and comb wool?

C. Development—Subject Matter

1. Occurrence

Wool fiber is finely scaled like fur, but is longer and inclined to curl. It is obtained from sheep raised in various parts of the world.

2. Uses

To the animal—Retains bodily heat.

To man—Wool, after being sorted for length of fiber, scoured, carded, and combed to remove grease and dirt, is spun into yarn for clothing fabrics.

Merino wool is short and fine; Lincoln wool is long and coarse; crossbred has the characteristics of both. The wooly covering of the sheep is called the fleece.

D. Summary

Wool of sheep is finely *scaled*, but the fibers are long and *curly* making it ideal for weaving into *winter* clothing fabric.

Part 4—Silk

A. Problem (stated at beginning of lesson)

B. Experiment

1. Apparatus (listed at beginning of lesson)

2. Directions

Boil the silk cocoon in water for 5 minutes.

- a. Begin at one end and pull off the other fiber until it unwinds as a single filament. Reel some of the filament on a pencil. Note its fineness.
- b. Compare this reeled filament with the specimen of raw silk.

3. Conclusions

Why is it possible to make much finer and lighter weight material from silk than from other fibers?

C. Development—Subject Matter

1. Occurrence

Silk is a filament spun by the larva of the silk moth. Most raw silk comes from China, Japan, Italy, France.

2. Uses

To the insect—The silk filament forms the protecting cocoon for the pupa stage of the silk moth.

To man—As a clothing material silk is the most beautiful fiber, and is so strong that it may be woven into very light weight material.

Silk filaments are not spun. Filaments from many cocoons must be reeled and twisted to form a single silk thread. Nearly 3000 cocoons are required to produce 1 pound of reeled silk. The silk filament is unwound from a cocoon after the pupa has been killed by boiling.

D. Summary

Silk is the most expensive clothing fabric because so many separate *filaments* are required to produce the thread.

APPENDIX D

A Book List of Titles Under the Various Categories

General Science

Our Environment	Wood & Carpenter	Allyn & Bacon
Elements of Science	Caldwell & Eikenberry	Ginn & Co.
General Science	William H. Snyder	Allyn & Bacon
Junior Science	John C. Hessler	Sanborn & Co.
First Year of Science	John C. Hessler	Sanborn & Co.
Early Steps in Science	Webb & Didcott	Appleton Co.
Everyday Problems in Science	Pieper & Beauchamp	Seott, Foresman & Co.
Science of Everyday Life	Van Buskirk & Smith	Houghton, Mifflin Co.
A First Year Course in General Science	Pease	Merrill
Foundations of Science	Bowden	Blakiston
Nature Study and Science	Trafton	Maemillan
Useful Science—Books I and II	Weed and Rexford	Winston

Astronomy

Reading with a Purpose (The Stars)	Harlow Shapley	American Library Assn.
A Beginner's Star Book	Kelvin McKready	Putnam
Half Hours with the Stars	Richard Proctor	Putnam
The Ways of Planets	Martha E. Martin	Harper Bros.
Astronomy for Young Folks	Isabel Lewis	Duffield & Co.
Trees, Stars and Birds	Moseley	World Book Co.
The Monthly Evening Sky Map	Leon Barritt, Brooklyn, N. Y.	367 Fulton Street, (Arbuckle Bldg.)
Why the Weather	Brooks	Harcourt, Brace & Co.
Astronomy from a Dipper	Clarke	Houghton, Mifflin Co.
Boy Astronomer	Collins	Lothrop
Heavens	Fabre	Lippincott
Voyage in Space	Turner	London
The Science of Discovery and Invention	Corwin	Wagner

Biology, Animal Life

Smaller Beasts	Deglish	Morrow
Wild Life and the Camera	Dugmore	Lippincott
Animal Life in Field and Garden	Fabre	Century
Story Book of Birds and Beasts	Fabre	Century
Wonders of the Instinet	Fabre	Century
All About Animals	Gask	Crowell
Sharp Eyes	Gibson	Harper
Minds and Manners of Wild Animals	Hornaday	Scribner's
Trail Makers	Meyer	Little
Lords of the Wild	Scoville	Morris
The Science of Plant and Animal Life	Corwin	Wagner

Biology, Aquatic Life

Sea Beach at Ebb Tide	Arnold	Century
Story of the Amphibians and Reptiles	Baskett	Appleton
Arcturus Adventure	Becbe	Putnam
Reptiles of the World	Ditmars	Maemillan
Children of the Tide	Henderson	Appleton
National Geographic Society, Book of Fishes		N. G. S.
Frogs and Toads	Overton	Museum of Brooklyn Institute of Arts and Sciences

Biology, Birds

Bird Stories	Burroughs	Houghton, Mifflin
Wake Robin	Burroughs	Houghton, Mifflin
Bird Life	Chapman	Appleton
Our Winter Birds	Chapman	Appleton
*What Bird is That?	Chapman	Appleton
*Birds Worth Knowing	Doubleday	Doubleday
How to Attract the Birds	Doubleday	Doubleday
Birds of the Field, Forest and Park	Gilmore	Page
Citizen Bird	Wright	Macmillan
Birds of Pennsylvania	Sutton	McFarland

Biology, Insects

American Boys' Book of Bugs, Butterflies and Beetles	Beard	Lippincott
Everyday Doings of Insects	Cheesman	McBride
How to Know Butterflies	Comstock	Comstock Pub. Co.
Insect Life	Comstock	Appleton
Spider Book	Comstock	Doubleday
Our Insect Friends and Foes	DuPuy	Winston
Book of Insects	Fabre	Dodd
Glow Worm and Other Beetles	Fabre	Dodd
Insect Adventures	Fabre	Dodd
Blossom Hosts and Insect Guests	Gibson	Newson
Clever Little People on Six Legs	Hawksworth	Scribner
Down in the Grass	Kellock	Coward, McCann
Bee People	Morley	McClurg
Honey Bees and Fairy Dust	Phillips	MacRae
Life Histories of American Insects	Weed	Macmillan

Biology, Plants

Wonder Book of Plant Life	Fabre	Century
Who's Who Among Wild Flowers and Ferns	Beecroft	Moffat
How to Know Mosses	Dunham	Houghton, Mifflin
Mushrooms	McDougall	Houghton, Mifflin
How to Know Ferns	Parsons	Scribner's
Some Common Edible and Poisonous Mushrooms	Farmers' Bulletin No. 796	Patterson
Book of Wild Flowers for Young People	Mathews	Putnam
How to Know Wild Flowers	Parsons	Scribner's
*The Soluable Gums	Handbook No. 4	Com'l Mus., Phila.
The Science of Plant and Animal Life	Corwin	Wagner

Biology, Trees and Forests

*Trees of Northern United States	Apgar	American Book Co.
*Handbook of Nature Study	Comstock	Comstock
State Forests of Pennsylvania	Bulletin No. 37	Dept. For. Waters
*Our Native Trees	Keeler	Scribner's
*Field Book of American Trees and Shrubs	Mathews	Putnam
*The Tree Book	Rogers	Doubleday
*Beautifying the Home Ground	Farmers' Bulletin No. 185	U. S. Dept. Agriculture
*Primer of Forestry, Part I	Farmers' Bulletin No. 173	U. S. Dept. Agriculture
*Primer of Forestry, Part II	Farmers' Bulletin No. 358	U. S. Dept. Agriculture
Woodcraft Manual for Girls	E. T. Seton	Doubleday
*The Nature Almanac	E. L. Palmer	Amer. Nature Assn.
The Leader's Guide in Junior Forestry Club Work	Coöp. Extension Dept. N. J.	State College Agriculture,
	New Brunswick, N. J.	
Familiar Trees and Their Leaves	Mathews	Appleton
School Book of Forestry	Pack	Appleton
Ten Common Trees	Stokes	Amer. Tree Assn.
Tree Habits	Illick	Amer. Tree Assn.
What Tree is That	Cheyney	Amer. Book Co.
Living Memorials to William Penn	Prepared by School Committee on Penn Memorials for Delaware Valley	E. E. Wildman, Administration Building, Board of Public Education, Philadelphia

Geology

*The Soil	King	Macmillan
*Elementary Geology	Tarr	Macmillan
*Elementary Physical Geography	Tarr	Macmillan
Real Things in Nature	Holden	Macmillan
Minerals,—How to Study Them	Dana	Wiley Co.
Gems and Gem Minerals	Farrington	Mumford
*The World's Minerals	Speneer	Stokes
This Earth of Ours	Fabre	Century
Stories of the Rocks and Minerals	Fairbanks	Educational Pub. Co.
Strange Adventures of a Pebble	Hawksworth	Scribner's
Earth and Its Story	Heilprin	Silver
Boy Mineral Collectors	Kelley	Lippincott
Field Book of Common Rocks and Minerals	Loomis	Putnam
Boy's Book of the Earth	Small	Dutton
Story of the Earth	Washburn	Century
Photographs of Snow Flakes, Frost, Dew	W. A. Bentley, Jericho, Vt.	

Chemistry and Physics

Heat and Health	Meister	Scribner's
Water and Air	Meister	Scribner's
Energy and Power	Meister	Scribner's
From Immigrant to Inventor	Pupin	Scribner's
Boy's Own Book of Great Inventions	Darrow	Macmillan
Masters of Science and Invention		Harcourt, Brace
Letters of a Radio Engineer to His Son	John Mills	Harcourt, Brace
Mechanical Devices in the Home	Allen	Manual Arts Press, Peoria, Ill.
The Book of Magic	Collins	Appleton
The Magic of Science	Collins	Revell
*High School Chemistry	Dull	Holt
*Modern Physics	Dull	Holt
*Chemistry and the Home	Howe & Turner	Scribner's
*Creative Chemistry	Slossen	Century
*Enriched Teaching of Science in the High Schools	Bureau of Publications, Teachers' College, Columbia University	
Beginnings of Chemistry	Beale	McCann
Amateur Chemist	Collins	Appleton
Story of Chemistry	Darrow	Bobbs-Merrill
Boys' Book of Physics	Clarke	Dutton
Boy's Own Book of Science	Darrow	Macmillan
Great Moments in Science	Lansing	Doubleday
The Science of Discovery and Invention	Corwin	Wagner

Electricity, Mechanical Toys, Inventions

Book of Electricity	Collins	Appleton
Machines and How They Work	Gibson	Lippincott
Boys' Home Book of Science and Construction	Morgan	Lothrop
Marvels of Modern Mechanics	Wilkins	Dutton
Magnetism and Electricity	Meister	Scribner's

General Reference

Handbook of Nature Study	Comstock	Comstock Pub.
Story Book of Science	Fabre	Century
American Natural History	Hornaday	Scribner's
Tales from Nature's Wonderlands	Hornaday	Scribner's
Science for Boys and Girls	Nichols	Lippincott
Keeping Up With Science	Slosson	Harcourt, Brace
Outline of Science	Thompson	Putnam
Common Science	Washburn	World Book Co.
Seaside and Wayside	Wright	Heath
Out of Doors in the Delaware Valley	Wildman	(In preparation)

* Teachers' Reference.

Biography

Famous Men of Science
Masters of Science and Invention
Hunger Fighters
Microbe Hunters
Boys' Life of Edison
Story of My Boyhood and Youth
Stories of Luther Burbank
Life of Pasteur

Bolton
Darrow
DeKruif
DeKruif
Meadowcroft
Muir
Slasser
Valley-Radot

Crowell
Harcourt, Brace
Harcourt, Brace
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Harper
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Scribner's
Doubleday